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THE EFFECT OF SYNTHETIC GROWTH SUBSTANCES ON THE YIELD AND QUALITY OF TOMATO FRUIT

By

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[Received on 5th May, 1959]

INTRODUCTION

In recent years such effort has been made to establish a physiological role of a new group of compounds generally known as "Growth Regulating Substances". This name is assigned to them because, when applied in a suitable manner and in the correct amount they will affect the growth of plants in various ways. This group includes hormones vitamine and auxins. Intensive research in proceeding in this particular field of Plant Physiology.

Boysen Jensen (1936) began experiments on the process of stimulus conditions in Avena coleoptile. A new impetus was given to the study of the subject when Went (1938) published his method for extracting growth substances and demonstrating the quantitative relationship between it and growth in avena coleoptile. Gustafson (1936-1940) developed a method of producimg partheno carpic fruit by the use of growth promoting substances. His work opened a new field for hormones to be applied. James (1941) published his work on the chemical difference between seeded and hormone induced partheno cyrpic tomato fruits by the use of Indole acetic acid and Indole butyric acid of 1% concentration. Rasmussen (1947) studied the physiological action of 2-4 D on dandelion. Batjer and Thompson (1948) worked on the effect of naphthelene acetic acid as locally applied to apples. Mitchell and Cullinan (1942) concluded that bud opening was stimulated by the application of Indoleacetic acid and Indole butyric acid. Ranjan and Kaur (1952) worked on the effect of pre-anthesis spray of methylnaphthoxy-acetic acid and development of seedless fruit. Osborne, Wain and Walker (1954) studied certain aryloxy acetic acid for inducing rooting and tomato setting.

In the present investigation effort has been made to see the effect of hormone applied along with nutrient solution and then sprayed.

METHOD AND MATERIAL

Tomato seedlings of Ponderosa variety were transplanted in earthern posts of medium size holding about 10 kg m of sand in August 1950. Fifty similar pots were arranged in ten rows of five each. First five pots served as control received only Hoagland and Snyders solution. Remaining forty-five pots were divided into three groups of 15 pots receiving the growth substances in the doses with nutrient solution. Each dose was replicated five times. Following hormones were used:—

1. Indole-3-Acetic Acid ... ... (I-3-A. A.)
2. Ortho-iso-prophylnitro phenyl carbonate ... (O.I.P.N.C.)
3. Phenoxy Acetic Acid ... ... (P. A. A.)

1% stock solution of hormones was prepared. First the hormone was dissolved in little absolute alcohal and then the volume was made up to the point by distilled water. Out of this stock solutions were made with water to have desired doses of 10, 20 and 30 p.p.m. The control pots did not receive any hormone, the treated ones were supplied with the respective doses once in a month together with Hoagland and Synder's complete nutrient solution. At the time of transplantation half the amount of nutrient solution and hormone required was supplied, later on one liter per pot of nutrient solution and hormone per month was applied. The pH of the solution applied ranged between 3·5. During pre-anthesis period the hormones in respective doses were sprayed on buds. Before the Anthers dehisced the stameas were removed, the style was cut off and hormone was sprayed at the cut surfaces. So Aqueous solutions of hormones were also locally sprayed.

Fruitling in hormone treated plants started one week earlier than the control plants.

Total number of fruit per plant and average weight of fruits per plant was recorded. Fruits selected at random were cut in two halves to see its partheno carpic condition. No fruit was completely partheno carpic, but different treatment produced different degree of-Parthcus-corpic condition. The quality of hormones treated fruits and control was compared. Since all the flowers were emasculated so sample were taken at random for analyses. The gain in dry matter was recorded after drying them in electric oven. Later on they were powdered for ash and dry matter analyses.

Analyses of the Dry Matter :

Dried fruit samples were anlysed for percentage of total nitrogen and protein nitrogen, by Kjeldal's method modified by Gunning to include Nitrate Nitrogen. Potassium, phosphorous and calcium were estimated by A.O.A.C. method.

Analyses of Fruit Juice :

The fruit juice was analysed for pH by Beckmans pH meter with glass and calomel electrode, ascorbic acid (vitamin c) by Dichlorophenol-indophenol method and Titratable acidity by titrating the fruit juice against N/10 NaOH.

Analyses of Fresh Fruit :

The quality of fresh fruit was assessed with reference to carbohydrate fractions-glucose, total sugar and starch by Lane and Eynon's method using Fehling solution A & B with Methylene blue as external indicator.

RESULTS AND DISCUSSION

An inspection of the table shows that the lower dose of I-3-A.A. did not bring about any significant increase in the number of fruits per plant. The two higher doses 20,30 ppm and all the doses of P.A.A. and O.I.P.N.C. brought about a significant enhancement in the number of fruits over the control. Increasing doses of I-3-A.A. and P.A.A. brought about increasing yield per plant. But O.I.P.N.C in increasing dose could notalter the yield significantly though the difference from the control was enormous.

Significant gain over the control in dry matter was visible in all the doses of hormone treatments except in 10 ppm I-3-A.A. O.I.P.N.C. seems to influence dry matter accumulation more effectively than any of the effective hormone Christiansen Kunz, Bonner and Thimann (1949) on auxin treated pea stem sections, they found geater increase in dry weight in auxin treated tissues as compared to control.

The conversion of starch into sugar in hormone treated tissues is known to be a common feature in ripening of fruits. Byron E. James (1941) in "the study of some chemical differences between the artificially produced partheno carpic fruits and seeded fruits of tomato", observed that the percentage of starch continued to decrease as the fruits ripened, and the percentage of sugar in the locules of partheno carpic fruits continued to increase. A review of the table shows a fall in the percentage of starch and a significant rise in the percentage of total sugar and glucose in many of the hormone treatments.

A shift of pH towards acedic side is another noteworthy feature of hormone treatments. It is well known that the influence of the pH of the medium on auxin activities is considerable. As some of the previous works show that the auxin activity it related to the undissociated acid on the hormone than to the total concentration of the hormones. The undissociated acid exists in the lipoidphase *e.g.* plasma membrane and lipo protein. It has been urged that the liyo philic properties of auxin may be assisting its absorption and translocation to variuos tissues. Whether this change in pH is a response by the plant to secure greater speed of migration of the synthetic hormone as a result of auxin activity is difficult to say. The fact, however, remains that the content of both titratable acid and hydrogen ion concentration show an increase in the fruits of the treated plants.

The increase in the total and protein nitrogen of tomato fruits from hormone treated plants has a parallel in the findings of Christianson, Kunz, Bonner and Thimann (1949) on the treated pea stems. A greater consumption of amino acids and a greater synthesis of protain in the hormone treated tissues as observed by Christianson Kunz, Bouner. Thimann (1949) in comparison to untreated ones is also reflected in the present investigation. Whether this increase in protein nitrogen is of any significant relation to auxin induced growth is difficult to say. There is no proportionality in the increase in protein synthesis and the increase in growth is conceded by Broughs and Burstorm (1954).

Struckmayer (1951) noted the calcium sparing action of hormones. The increased breakdown of protopectin in plants treated with synthetic auxin, perhaps

EFFECT OF SYNTHETIC GROWTH SUBSTANCES ON THE YIELD AND QUALITY OF TOMATO FRUIT

Observations	Control	Indoll -3 Acetic Acid 10 ppm	20 ppm	30 ppm	Ortho-iso-Propyl Nitro Phenyl Carbamte 10 ppm	20 ppm	30 ppm	Phenoxy Acetic Acid 10 ppm	20 ppm	30 ppm	cd at 5%
No. fruits ...	19	21	24*	28*	30*	29*	32*	25*	29*	36*	3·0
Yield in Lbs. ...	4·2	5·4*	7*	8·2*	12·2*	11·6*	11·8*	5·4*	10·8	13·4*	0·09
Dry wt./100 gm. fresh wt. ...	5·0	5·0	6·2*	6·0*	7·0*	7·2*	6·6*	6·4*	6·6*	6·1*	0·9
Gm. Glucose/100 gm. fresh wt. of fruit	4·2	4·4*	4·3*	3·7	5·0*	6·2*	5·2*	5·0*	6·1*	6 3*	0·19
Gm. Total sugar/100 gm. fresh wt. of fruit	4·6	4·9*	4·7	4·0	5·6*	6·9*	5·8*	6·0*	6·6*	7·0*	0·14
Gm. Starch/100 gm. fresh wt. of fruit ...	0·39	0·36	0·30	0·31	0·37	0·38	0·32	0·35	0·35	0·37	0·04
pH	3·8	3·7	3·56	3·7	3·8	3·8	3·6*	3·7	3·7	3·6*	0·12
Titratable acidity, c.c. of fruit juice required to nutralize/10 c.c. N/10 NaOH	97·0	72·6*	75·3*	71·3*	83·6*	77·0*	82·6*	78·6*	78·0*	82·0*	4·3
Ascorbic acid-Vitamin C-mg/ 100 gm. esh wt. of fruit	37·6	40*	41*	40*	43*	41*	40*	40*	42*	41·6*	0·102
Mg. Total N/100 gm. dry wt. of fruit ...	0·93	1·02*	1·5*	1·1	2 2*	2·3*	2 06*	1·7*	1·8*	1·7*	0·05
Mg. Protein N/100 gm. dry wt. of fruit	0·59	0·64*	1·0*	0·67*	1·43*	1·53*	1·16*	1·03*	1·16*	1·1*	0·04
Mg. Potassium/100 gm. dry wt. of fruit...	1·0	0 91	0·93	0·90	1·04	1·16*	1·10*	1·1*	1·0	1·2	0·09
Mgm. Phosphorus 100 gm. dry wt. of fruit	0·57	0·53*	0·58*	0·59*	0·56	0·65*	0·53*	0·56	0·44*	0·65*	0·01
Mgm. Calcium 100 gm. dry wt. of fruit	0·90	1·01*	1·02*	1·00*	1·05*	1·10*	1·12*	1·10*	1·06*	1·04*	0·09

* values significant at 5% level.

keeps more calcium mobile because less of it is tied up in the primary wall, as calcium bonds between carboxyl group of the chain of anhydrogalacturonic acid of protopectin. In the present investigation increase in calcium may be due to the action of hormones. Except in 20 and 30 ppm and I-3-A.A., 20 P.P.M., O.I.P.N.C. and 20 ppm PAA nowhere the percentage of phosphorous increased significantly over the control, with 20 ppm PAA a steep fall was recorded in hormone treated fruits. Bonner (1938) and his school of thought hold that I-3-A.A. affects growth and respiration through the metabolism of phosphates. Phosphate metabolism has been shown to be of permanent importance for the transfer of energy, it would appear that I-3-A.A. can therefore regulate the flow of energy in various other reactions in the plants. Bonner (1950) looks upon the organic acid metabolism as a mechanism which provides a substrate for auxin action. According to this view organic acid metabolism together with indegenous respiration generates high energy phosphate. As the migration or utilization of which is controlled by the auxin.

From the examination of the table it is clear that except in I-3-A.A. in all other auxin treatments the percentage of potassium has increased in tomato fruits. The increase in potassium seems to reflect the cause of increased protein and acidity. It was pointed out by Cooil (1950) with the increased supply of potassium, there was increase in citric acid. Potassium might have been absorbed from the nutrient solution and would have increased the acidity as found in this investigation. It may be that P.A.A. and O.I.P.N.C. would have assisted in the luxury absorption and assimilation from the growth mediums and part of the absorbed amount would have been assumed in the synthesis of protein. I-3-A.A. would have failed to cause a luxury absorption and the absorbed amount might have been consumed in protein synthesis. So this might have brought about a fall.

ACKNOWLEDGEMENT

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SUMMARY

All the hormones in 10, 20 and 30 p.p.m. doses promote the quality and bring about high yield. Potassium content of fruits increase in all cases except I-3-A.A. Phosphorus does not follow the same trend.

REFERENCES

1. Batjer L. P. and T. H. Thompson, The transmission effect of Naphthelene acetic acid on Apple-drop as determined by local application, *Proc. Amer. Soc. Hort. Sc.*, **51** : 77-80, 1948.

2. Bonner D. M., Relation of environment and Physiological properties of synthetic growth substances to the growth reaction, *Bot. Gag.*, **100** : 200-14, 1938.

3. Boysen Jensen P., Growth hormones in plants. Translated by Avery G. S. and P. R. Burkholder, McGrow Hills New York, 1936.

4. Burroughs A. M., Changes in the respiration rate of ripening apples, *Proc. Amer. Soc ,|Hot. Sc.* **19** : 225-35, 1922.

5. Burstrom H., Photosynthesis and assimilation of Nitrates by wheat leaves, *Ann. Royal Agr. College Sweden*, **11(1)S**, 1943.

6. Burstrom H., Nitrate nutricrits of Plants, *Ann., Royal Agr. College-Sweden*, **13**(1)-86, 1945.

7. Byron E. James, Chemical difference between artifically produced partheno corpic fruit and normal seeded fruit of tomato, *Amer. Jour. Bot.*, **28**, 639-46, 1941.

8. Christiansen G. S., L. J., Kunz, W. D. Bonner and K. V. Thimann, Action of growth inhibitors on carbohydrate metabolism of *Pea Plant Physiology*, **24** : 178-81, 1949.

9. Cooil B. J., Potassium deficiency and excess in Guayule II-Anion-Cation balance in leaves, *Plant Physiology*, **23**-405-24-1948.

Mulder's Review—Annual Review of Plant Physiology, 1950.

10. Gustanfson F. G., Inducement of fruit development by growth promoting chemicals. *Proc. Nat. Acad. Sci-washtt*, 628-36, 1936.

11. Gustanfson F. G., Parthenocorpic and normal fruit as compared to percentage of setting and size, *Bot. Gaz.* **102** : 280-86, 1940.

12. Mitchell J. W. and Frank P. Cullinan, Effect of growth regulating chemicals on opening of vegetative and floralbuds of peach and pear, *Plant physiol*, **17** : 16-26-1942.

13. Osborne D. J., R. L., Wain, and R. O. Walker, Studies on plant goowth regulating substances: Activity of certain Aryloxy aceaticaced for inducing rodting and for tomato setting. *Jour. Hort Sci.*, **38**-44-52, 1952.

14. Ranjan S. and R. Kaur., Hormone induced Parthenocarpy in *Hibiscus esculentus* and Solanum melongena, *Curr. Sci.*, **20** : 70-1951.

15. Rasmussen L. W., Physiological action of 2-4-D on Dandilion, *Plant Physiology*, **22** : 377-92, 1947.

16. Went F. W., Specific factors other than anxins affecting growth and root formation, *Plant Physiology*, **13** : 55-80, 1938.

17. Went, F. W., Transplantation experiments with pea, *Amer. Jour. Bot.* **25**(1) 44-55, 1938.

A PRELIMINARY SURVEY OF THE VEGETATION OF MUZAFFARNAGAR DISTRICT IN THE UPPER GANGETIC PLAIN U. P.

By

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[Received on 13th March, 1959]

INTRODUCTION

Since Dudgeon (1920) described Ecology of the Upper Gangetic Plain, various botanists have given the vegetation from different places in the Upper Gangetic Valley. Varma (1936) studied the ecology in the vicinity of Lucknow, Puri (1954) studied the 4 types of plant communities in Siwaliks ; while Puri and Dabral (1957) further correlated their studies with the succession of ground flora species in the forest plantations in New Forest, Dehra Dun. More recently Misra (1959) gave a description of the plant communities in the Gangetic Plain.

In many parts of the district vegetation is poorly represented owing to centuries of abuse, and has resulted in violent erosions on the banks of Ganges and Yumna forming ravines. These are now completely denuded, that they are destitute of vegetation, except for the desert flora, *e.g.*, *Acacia arabica* Willd. *Capparis aphylla* Roth., *Zizyphus sp.*, etc. The principal cause of the existence of these erosions are (1) the relentless pressure of the multiplying population, both human and bovine, (2) unlimited and controlled grazing (3) faulty agricultural practices by the population of the district. Preliminary studies on the vegetation of Muzaffarnagar district have been made, and are being described here ; detailed studies on the ravine flora will be given in a separate communication.

Physical Features and Drainage :

Muzaffarnagar is situated in the 'doab' of rivers Ganga and Yumna between the district of Meerut on the South and the Saharanpur on the North. On the west Yumna separates it from Panipat and Thaneshar tehsils of Karnal district (in East Punjab) and in the east Ganga separates it from Bijnor district. Thus the district is flanked on either side by 'Kandars' of Ganga and Yumna giving it an elevation of about 1,000 ft. above sea level.

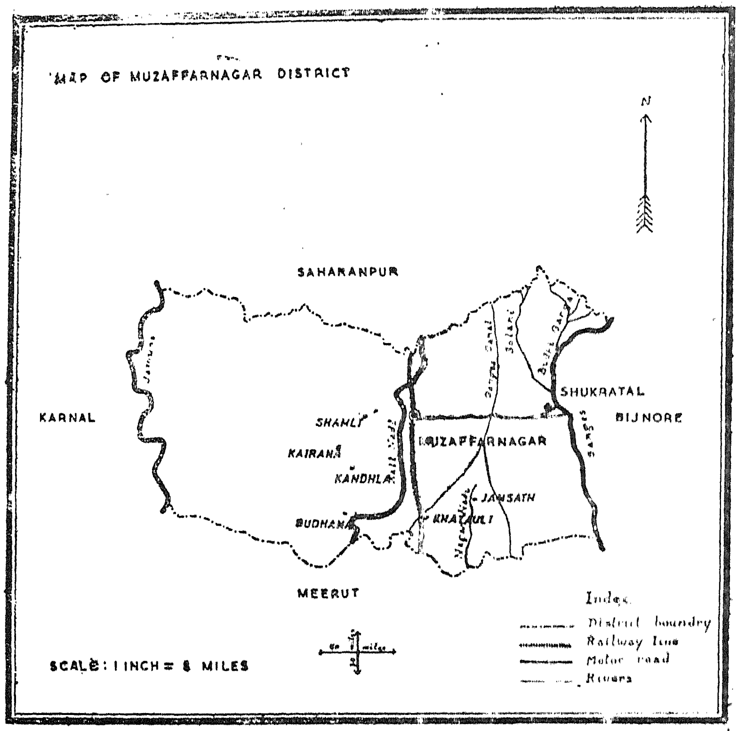
The district is drained by a canal of the river Ganga near Khatauli, and rivers Solani, Budhiganga and Kalinadi. The main stream of Ganga is about 24 miles from the town, and touches the boundary of the district at Sukhartal. On the west flows river Yumna, forming the boundary of the district.

Climate :

The climatic conditions have been well described by Dudgeon (1920) and some of the salient features have been given by Misra (1958).

The matereological data and the phenological observations have shown that the year is divisible into 6 seasonal phases, according to Misra (1959) known as 'Ritus'.

Since the district is close to Swalik ranges of Saharanpur, the climate on the whole is dry monsoonic with a mean annual temperature of 75-85^{0}F (the highest with a maximum of 110^{0}F in June). In January the mean maximum temperature is about 60^{0}F while the mean annual minimum temperature is about 30-40^{0}F.



Rainfall :

The annual rainfall is about 30-40″ falling mainly during the monsoon period. Rainfall at various stations in the district have been represented by the rainfall paterns ; Fig. 1 & 2.

There is a well marked change of seasons in the district. June being the hottest and January being the coldest month of the year. Corresponding to the changes in the season, natural vegetation also changes and have been described by Misra (1959) from the Gangetic Plain. In general during rainy season due to increase in soil water content and decrease in air and soil temperature herbaceous vegetation springs up. In winter season October to February, temperature is low and humidity of the air is also lower. The number of plants per unit area decreases. Summer season starts from March ending till June when temperature increases and humidity becomes low. The water content of soil also decreases, all the annuals die and trees give a new flash of leaves.

Rock and Soil :

As the district lies in the south of Saharanpur Siwaliks, extension of terriary Siwalik ranges touch the boundary of the district at some places. The plain areas are associated with eroded hill sides and alluvim.

Biotic Factor :

On account of the heavy human population and agriculture natural vegetation is poorly represented in the district. The low lying areas are a conspicious feature, arising naturally as gullies, depresion or artificially dug ponds and tanks. Grazing and cultivation are very old practises among the population of the district, so much so, that they have modified the development and succession of the vegetation. *Saccharum officinarum* (Sugar cane) is the chief produce of the district.

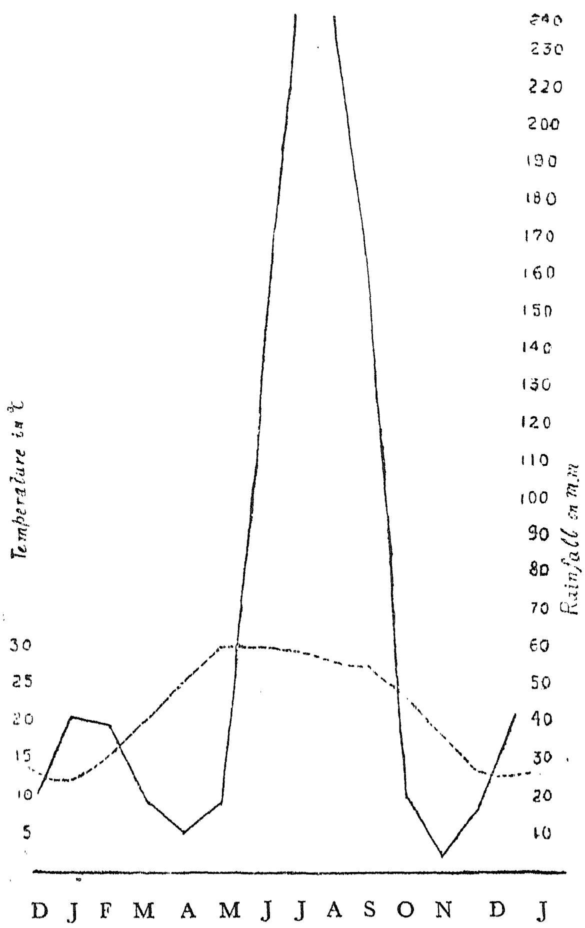


Fig. 1.—Ombothermic curve showing the relation between rainfall and temperature

Vegetation :

As has been pointed out earlier there is a marked change in the vegetation of the district in different seasons of the year. There is progressive developmental tendency among the plant communities towards the climatic types. This has been alled as the 'Topographic Succession' by Dudgeon (1920).

The topographic succession here can be represented as (1) Thorn scrub stage (2) Dry meadow stage (3) Wet meadow stage and (4) Hydrophytic stage.

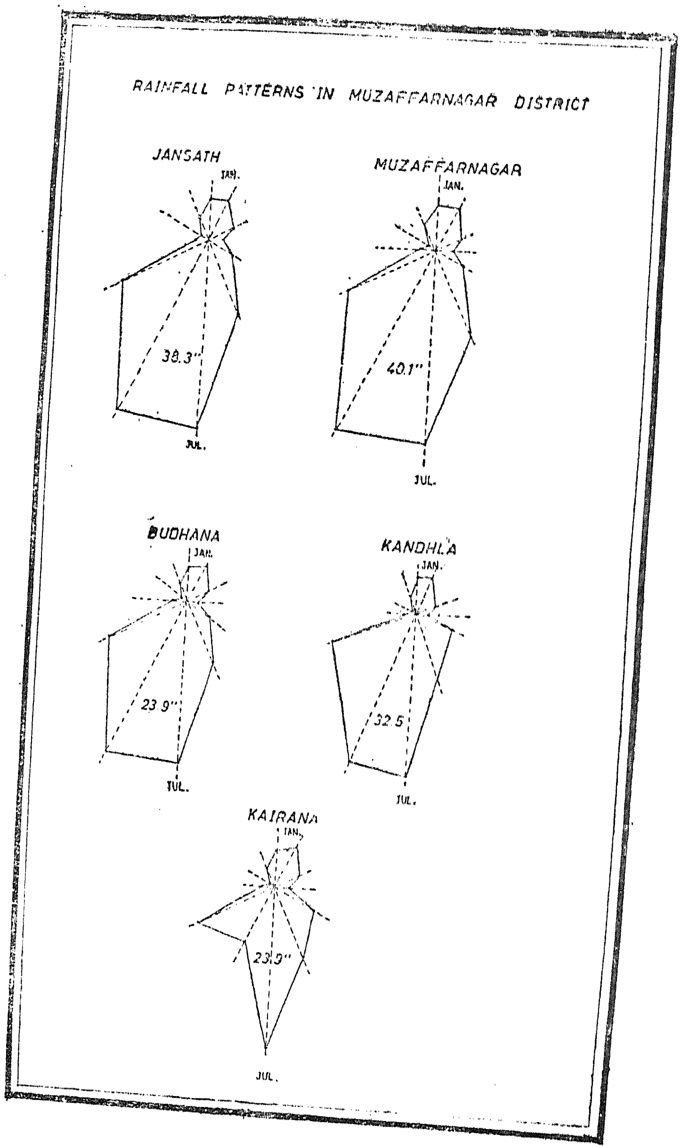
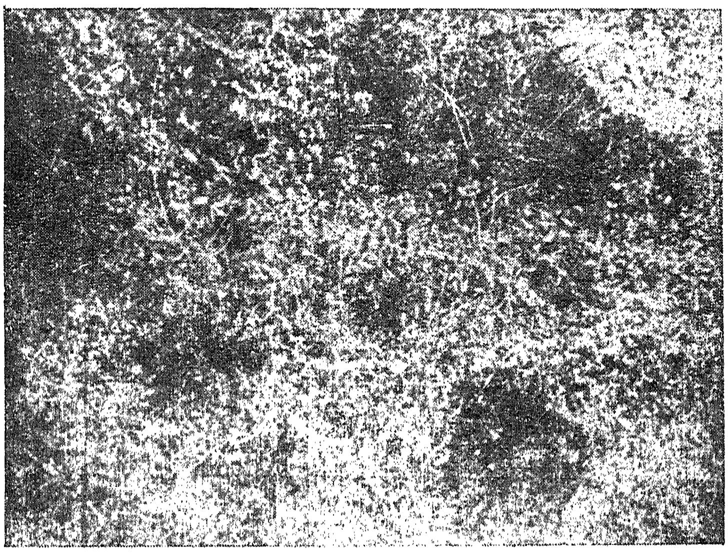


Fig. 2.

Thorn Scrub Stage :

This stage is represented by plants like *Acacia arabica* Willd., *Flacourtia indica* Merr., *Calatropis procera, Jatropha gossipifolia* Linn., *Capparis aphylla* Roth., *Butea*

monosperma Kuntz., *Adhatoda vasica* Nees, and some grasses like *Aristida, Andropo gon, Chloris* and *Apluda.* (Ph. 1).



Ph. 1.—*Capparis-Zizyphus* and *Adhatoda* Association. Vegelation below *A. arabica* and *Dalbegia sissoo* on the banks of Ganges canal at Khatauli

Acacia arabica Willd. is very common in some what moist situations and *Butea monosperma* Kintz. represent a scrub vegetation in the low lying areas. *Acacia arabica* is frequently associated with *Dalbegia sissoo* Don., in small quantity with shrubs of *Adhatoda vasica* Nees., *Capparis sepiaria* Linn., *Lantana camara* Linn., *Zizyphus mauratia na* Lamk. and *Phoenix*, etc. There are a number of climbers on *Zizyphus* and *Acacia,* e. g., *Hemidesums indicus* Br., *Cocculus villosus* Dc., *Tinospora cordifolia* Miers., *Coccinia indica* W. & A., Vitis spp., and *Abrus precatorius* Linn. Common species on the ground are *Vernonia cinera* Less., *Peristrophe bicalyculata* Nees., *Sida cordifolia* Linn. and *Achyranthes aspera* Linn.

In this stage the ground vegetation only shows structural responses to the seasons, small patches of forest just exist because the land is unserviceable and not easily accessible ; otherwise the vegetation is continuously cut for fuel and in all probality, it would develop on the areas occupied by wet and dry meadows, if the biotic factors are removed.

Dry Meadow Stage :

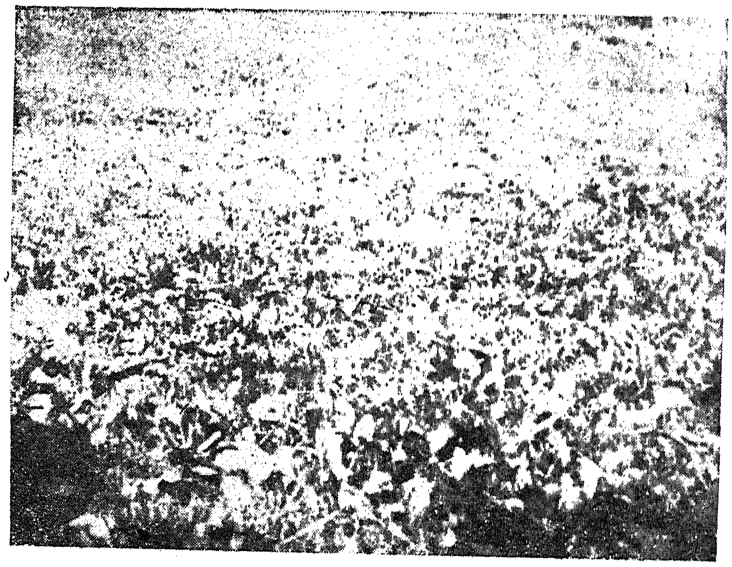
This stage is represented on the level grounds between the low lying lands and cultivated fields. The annual and perennial grasses (with annual shoots) give a seasonal aspect to the communities. During the rainy season this is a closed community of *Boerhavia diffusa* Linn., *Indigofera enneaphylla* Linn., *Cyanodon dactylon* Pers., *Evolvulus alsinoides* Linn., *Convolvulus pleuricautis* Chois., *Justicia diffusa* Willd.

After the rains *Cassio tora* Linn., *Eragrostis tenella* R. & S., *Rungia repens* Nees., *Heliotropium strigosum* Willd., *Tephrosia purpurea* Pers., and *Euphorbia thymifo lia* Burm.

are present. Other common plants are *Convolvulus arvensis* Linn., *Lepidagathis trinervis* Nees., *Vernonia cinera* Linn., *Corchorus antichorus* Roeush., *Sida humulis Calatropis procera* R. Br. and *Launea asplenifolia,* inspite of grazing ; while in summers and dry seasons the community becomes open and most of the plant resume a prostrate habit. Thorny shrubs and trees may be present that are spared by man and animals. In the areas that are heavily grazed *Aristida adscensionis* Linn., is dominant.

Wet Meadow Stage :

This stage is seen near the pools and puddles where water during rainy season gets stored up. The substratum of these pools remains covered with water 4 or 9 months following July each year. During summers it receds even up to the centre of these pools ; while during rainy season it may extend even upto the dry meadows. As the water receds from the margins in the post monsoon dry season mud cummunities develop. The common plants of the community are *Cynodon dactylon* (Linn.) Pers., *Rumex dentatus* Linn., *Scirpus maritimus* Linn., *Ranunclus scleratus* Linn. *Cyperus difformis* Linn., *Fimbristylis diphylla* Vahl., *Eragrostis tenella* R. & S., *Polygonum plebejum* Bv., *Sphaeranthus indicus* Linn. etc. (Ph. 2).



Ph. 2.—Wet Meadow Stage *Cynodon dactylon*

In the areas of intense biotic inteterference annuals are replaced by perennials the common plants are *Juncus pygmaeus* Cl., *Potentilla supina* Linn , *Gnaphalium indicum* Linn., *Grangea maderaspatana* Poiv., *Rumex dentatus* etc.

Besides that the following plant communities are very well seen at some places—

(1) *Caesulia axillaris* community.

(2) *Typha longifolia* community.

(3) *Ip omea* pure or mixed with *Eichchornia.* (Ph. 3).

(4) *Polygonum glabrum* community.

Ph. 3.—*Eichchornia-Ipomea* community in the wet meadow stage.

Hydrophytic Vegetation :

This type of vegetation shows a definite succession in the monsoonic pools, where water during the rainy season gets stored up ; in which free floating, attached, sub-merged and amphibious form are found.

According to Misra (1959) the subaqueous withering of the alluvial parent material forms a clayey substratum the thickness of which varies with its age. During the acqous phase, it is occupied by communities of submerged, floating leaf forms and amphibious plants.

Common free floating plants are *Ceratophyllum demersum* Linn., *Azolla pinnata Lemna minor, Wolfia aryhiza* Wimm ; *Trapa bispinosa* Roxb. and *Eichchornia* species. During winter *Azolla pinnata* is so much that the whole pool looks brown. Besides that there are some algae present forming the plankton formation in these pools,

common being *Spirogyra Cladophora, Oedogonium, Vaucheria* and *Hydrodictyon* species. (Ph. 4).

Ph. 3.—Mixing of hydrophytic vegetation with wet meadow stage during winters. Floating is *Azolla pinnata* and *Marsilea* sp.

Common submerged plants are *Hydrilla verticillata* Royle., *Potamogeton pectinatus* Linn., *Vallisneria spiralis* Linn., *Zanichellia palustris* Linn., *Chara* sp. and *Jussia* sp.

Fixed aquatic plants are *Thypa elephantina, Ranunculus scleratus* Linn., *Scirpus maritima* Linn. *Nelumbium* sp., *Polygonum glabrum.* In shallow waters *Ipomea reptans* Poir., *Panicum paspaloides* Poirs., *Panicum punctatum* Burm. and *Polygonum glabrum* are common.

These plants arise in quick succession from the seeds, rhizomes and rootstocks of previous year's, stand, embeded in substratum. During winters when the water is clear they attain their maximum luxurience.

The existence of ecotones with admixture of species from the adjoing communities is quite common in the area.

The study shows that apart from the seasonal climatic changes in the plant communities there is a gradual but progressive developmental tendency among them towards the climatic type. Within a course of year seasonal changes of the flora takes place, and so we can say that the vegetation of the district consists of a mixed population of plants.

ACKNOWLEDGEMENTS

The author is deeply indebted to Dr. G. S. Puri, Regional Botanist, Botanical Survey of India, Poona for his kind help and encouragement.

REFERENCES

Dudgeon, W., 1920, A contribution to the ecology of the Upper Gangetic Plain, *J. Indian Bot. Soc.*, 1 : 296-324.

Duthie, J. F., 1903-1929, *Flora of the Upper Gangetic Plain and the adjacent Siwalik and Sub-Himalayan tracts, Calcutta.*

Misra, R., 1959, The status of the Plant Communities in the Upper Gangetic Plain, *J. Indian Bot. Soc.* 38 : 1-6.

Misra, R., 1946, A study in the ecology of lowlying lands, *Indian Ecol.* 27-46.

Misra, R., 1958, The study of tropical vegetation in Madhya Pradesh and the Gangetic valley, *Study of Tropical vegetation* UNESCO Proc. *Kandy symposium*, 74-83.

Misra, R. & G. S. Puri, 1954, *Indian Manual of Plant Ecology*, English Book Depot, Poona.

Puri, G. S., 1950, Soil pH and Forest Communities in the forests of Dehra Dun valley, U. P., India, *Ind. For.*, 76 : 292.

Puri, G. S. & S. N. Dabral, 1957, Succession of ground flora species in the forest plantations of New Forest, Dehra Dun, *Ind. For.*, 83 (9) 551.

Saxton, W. T., 1924, Phases of vegetation under monsoon conditions, *J. Ecol.* : 12.

A PRELIMINARY SURVEY OF THE VEGETATION OF NAINITAL IN KUMAON HIMALAYAS

By

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[Received on 13th March, 1959]

INTRODUCTION

Being the summer capital of Uttar Pradesh and a health resort, Nanital is visited by numerous tourists, naturalists and students every year during summers. Botanists who have earlier visited the locality include Champion, Duthie, Davidson, Jacquemont, Kenoyer, Osmaston, Royle, Strachey, Thompson, Winterbottom and others. Results of Strachey were published in a catalogue in 1906, while Osmaston published a forest flora for Kumaon (1927), giving mainly the shrubs and trees, he did not include the herbaceous vegetation. Jain (1956) gave a list of plants collected by him during May and June. Bhargava and Gupta (1958) compiled a list of the plants flowering in different months of the year, based on their own collections and a card index prepared by Champion.

A brief account of the observations on the vegetation is being presented here, as made by the author during his stay for several years at Naini Tal. Plants were collected in different seasons of the year. They are preserved in the herbarium, Government College, Naini Tal.

Topography and Physical Features :

Naini Tal is situated in Kumaon Himalayas about 22 miles from Kathgodam, in the valley of Gager range running east and west, bounded on the north by peak of China (2856 m.) continued by Alma peak and sher-ka-danda to the eastern extermity, where the ridge descends almost to the level of the lake. On the West the rugged hill of Deopatta rises to an height of about 2662m. diminishing gradually towards east. Eastern boundary is a pass through which surplus waters of the lake find an exit.

The lake is situated at an elevation of 2100m., its length, breadth and depth is about 1500, 500 and 30 meters, respectively. In the lake itself there is a sulphur spring and as also outside it near Tallital bazar.

Climate :

The precipitation is mainly derived from the south west monsoons and falls mainly during the months of June to August. The average rainfall is about 226cm. Snow falls during winters and stays for sometime on the peaks. The average humidity is about 82%.

The average maximum temperature is about 85°F. during summers and 65°F. during autumn and the average minimum temperature is about 32°F.

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Geology and Soil :

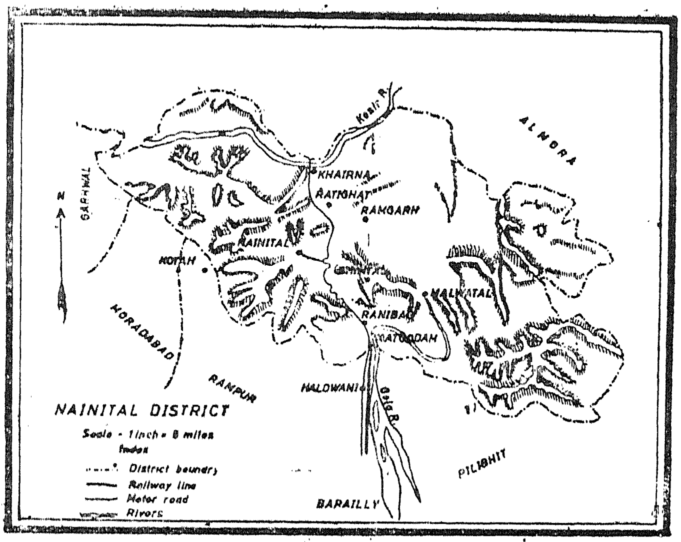
The forests are mainly on gnessis and schists, extending over quartzites, granites, limestones and shales. The soils show a wide range and are formed by the decomposition of these rocks.

Biota :

The influenee of man and animals is well marked on easily accessible forests. As all the oaks are good fodder for cattle, by continuous lopping large blanks have come into existence, or these forests have been converted into serub stage. This scrub passes into grasslands or give place to bushy secondary growths, usually consisting of species of *Berberis, Spiraea, Rubus, Daphne, Prinsepia* and *Crataegus.*

Vegetation :

There is a great diversity of plant groupings ranging from life on open water to that on open land, woodland and rockycliffs on the roadsides. The following types of vegetation is seen and is being given as under.



VEGETATION ON THE WOODLANDS

No dense forests are present in the locality, due to continuous biotic influence, except on some unacessible and protected ridges. The highest peak of the locality is the China peak about 2½ miles from the lake. Besides that Snow view and Lariakanta are situated on the north east of the town, Landsend is the abrupt end of a road and Dorothy's seat (2546m.) and Tiffin top are other peaks visited by naturalists, tourists, and students alike.

The vegetation on the ridges of these peaks is almost similar and typical of the Himalayan moist temperate type (Champion 1936) consisting of mostly the oaks and conifers. The conifers have come up as a result of the disturbance in the oak climax, either naturally or by artificial means such as human interference in form of felling, fire and cultivation.

The vegetation can be classified as :

(*i*) The lower oak conifer forests

(*ii*) The middle oak-conifer forests

(*iii*) The upper oak-conifer forests

(*i*) *Lower Oak-Conifer Forests* :

These forests consist chiefly of ban oak, *Quercus incana* Roxb. and when well developed form a dense canopy, but are generally seen in the locality in a degraded form. In the damp ravines there may be mixture of other species such as *Rhododendron arboreum* D. Don. (15 - 20%), *Pieris ovalifolia* D. Don (5 – 8%) and *Carpinus vimnea* Wall. *Euonymus pendulus* Wall., *Ilex dipyrena* Wall., *Betula alnoides* Ham., *Pinus roxburghii* Sarg. and *Cedrus deodara* Loud., in small proportions.

The common shrubs and herbaceous undergrowth is of *Viburnum cotinifolium* D. Don., *Desmodium sp.*, *Indigofera gerardiana* Wall., *Berberis lycium* Royle, *Berberis asiatica* DC., *Lonicera quinquelocularis* Hardw., *Strobilanthus dalhousianus* Wall., *Leptodermis lanceolata* Wall., *Wikstroemia canescens* Meissn., *Spiraea vaccinifolia* D. Don. and *Myrsine africana* Linn.

Common Herbs are *Plectranthus rugosus* Wall., *Myriactis wallichii* Less., *Agrimonia eupatorium* Linn., *Boenninghausenia albiflora* Rchb, *Viola canescens* Wall., *Galium asperifoium* Wall., and *Pimpinella diversifolia* DC.

Hedera nepalensis Koch., *Smilax parviflora* Wall., *Vitis himalayana* Bran. and *Rosa moschata* Mill. are the common climbers that can be seen.

(*ii*) *Middle Oak-Conifer Forests* :

These type of forests consists of mainly the moru oak *Quercus dilatata* Lindl. and become more luxurient in the damper climate than the ban oaks. There is greater mixture of secondary species in the top storey ; mainly of deciduous species. The main tress of this zone are *Quercus dialatata* Lindl., *Rhododendron arboreum* D. Don., *Machilus duthei* King., *Betula alnoides* Ham., *Euonymus pendulus* Wall., and *Lindera pulcherrima* Benth., *Eruya acnminata* Dc.

The shrubby undergrowth is of *Spiraea vaccinifolia* D. Don., *Viburnum cotinifolium* D. Don., *Sarcococca pruniformis* Lindl., *Deutzia corymbosa* Br. and *Myrsine africana* Wall.

The growth of epiphytic herbs is less pronounced than in ban forests and that of mosses less than in *Quercus semicarpifolia* forests, but the epiphytes are non the less conspicuous during monsoons.

(*iii*) *Upper Oak-Conifer Forests* :

These forests form the upper limit in the locality and form dense crops. The main component of these forests is the Kharsu oak, *Quercus semicarpifolia* Sm. associated with small proportions of *Betula alnoides*, *Rhododendron arboreum*, *Aesculus indica* Hiern. and Acers. There are no natural grooves of deodar, and other conifers besides *Cedrus deodara* Loud., planted on the China ridge are *Abies pindrow* Spach.,

Picea smithiana Boiss., *Pinus excelsa* Wall., *Juniperus pseudo-sabina* Fisch., *Juiperus communis* Linn., and *Juniperus excelsa* Brand., *Cupressus torulosa* D. Don., and *Cupressus funebris* Endl., are also not uncommon.

Common shrubs are *Rosa sericea* Lindl., *Viburnum cotinifolium, Viburnum foetens* Dcne., *Cotoneaster acuminata* Lindl., *Strobilanthes walichii* Nees., *Salix elegans* Wall., *Arundinaria spathiflora* Trin., and *Arundinaria falconeri* Benth. form dense thickets at some places.

VEGETATION ON THE OPENLANDS

This type of vegetation is commonly found on the upland levels and hill tops, mainly at China peak, Lariakanta and Dorothy's seat. The dominant plants are *Anemone obtusiloba* Linn., *Aquilegia pubiflora, Artemisia parviflora* Wight., *Anaphalis triplinervis* Clarke., *Fragaria vesca* Linn., *Gentiana argentia* Royle., *Habenaria intermedia* D. Don., *Drosera peltata* Sm., *Polygonum sp.*, *Polygala crotalariodes, Potentilla fulgens* Wall., *Potentilla nepalensis* Hook. f., *Pedicularis pectinata* Wall., *Ranunculus laetus* Wall., *Satyrium nepalensis* D. Don., and *Taraxcum officinale* Wigg.

VEGETATION ON ROADSIDES AND ON ROCKYCLIFFS

The vegetation on the road-sides form a conspicuous aspect of the vegetation. After the rains the rocky-cliffs are completly covered with the vegetation, consisting mainly of bryophytes, mosses and angiosperms. Road-sides are also covered with thick vegetation of angiosperms and ferns.

The common bryophytes that are usually found are species of *Targionia, Fimbriaria, Plagiochiasma, Riccia, Marchantia, Anthoceros, Reboulia, Notothylas, Pellia, Dumortiera* etc. Prothallii of ferns are very common after the rains. Chief mosses found are species of *Pogonatum* and *Funaria.*

Angiosperms that are attached to the rocks are *Platystemma violaides* Wall., *Bergera ligulata* Engel., *Saxifraga brunoniana* Wall., *Tillea pentendra* Royle. *Sedum rosulatum* Edgew., *Sedum adenotrichum* Wall., *Begonia amoena* Wall., *Begonia picta* Sm., *Wulfenia amherstiana* Benth. and *Geranium sp.*

The road-side vegetation consists of the following trees, shrubs, herbs, climbers and ferns.

Trees : *Aesculus indica* Hiern., (Pangar), *Acer pictum* Thunb., *Cedrus deodara* Loud., (deodar), *Cupressus funebris* Endl., (Surai), *Cupressus torulosa* D. Don., *Prunus padus* Linn., *Pinus roxburghii* Sarg., (Chir), *Pieris ovalifolia* D. Don., (Ayar), *Populus ciliata* Wall , (Pahari pipal), *Pinus exceelsa* Wall., (Kail), *Quercus incana* Roxb, (ban), *Quercus dilatata* Lindl., (Moru), *Quercus semicarpifolia* Sm., (Kharsu), *Symplocos crataegoides* Ham. (Lodra), *Sarauja nepalensis* DC., (Geu).

Shrubs : *Crataegus crenulata* Roxb., (Ghingara), *Cotoneaster microphylla* Wall., (Gheri), *Callicarpa microphylla* Vahl., *Cyathula tomentosa* Moq., *Colquhounia coccinea* Wall., *Deutzia corymbosa* Br. (Gugti), *Daphne payraceae* Decne., (Satpura), *Hypericum cernuum* Roxb., (Piunli), *Hamiltonia suaveolens* Roxb., *Inula cappa* DC., *Inula cuspidacta* Clarke., *Jasminum humile* Linn., (Jai), *Leptodermis lanceolata* Wall., (Padera), *Sarcoca pruniformis. Spiraea canescens* Don., (Mairala), *Senecio rufinervis* DC., *Verbena officinalis* Linn., *Vitex negundo* Linn., *Wikstroemia canescence* Meissm., and *Zanthoxylum alatum* Roxb. (timru).

Herbs: *Ainsliaea aptera* DC., *Arenaria orbiculata* Royle., *Agrimonia eupatorium* Linn., *Anotis calycina* Hk.f., *Aster molliusculus* Wall., *Aster asperulus* Nees., *Anaphalis cinnamomea* Clarke., *Anaphalis adnata* DC., *Ajuga bracteosa* Wall., *Achyranthes aspera* Linn., *Arisaema sp.*, *Boenninghausenia albiflora* Rcb., *Bupleurum falcatum* Linn., *Bidens pilosa* Linn., *Bidens wallichii* Dc., *Cardamine impatines* Linn., *Crotalaria sp.*, *Caucalis anthriscus* Scop., *Campanula colorata* Wall., *Cynoglossum wallichii* G. Don., *Cannabis sativa* Linn., *Commelina sp.*, *Craniotome versicolor* Rchb., *Dipsacus inermis* Wall., *Dicliptera bupleuroides* Nees., *Erigeron linfolius* Wild., *Erigeron multicaulis* Wall., *Epilobium roseum* Schreb., *Fagopyrum cymosum* Meissn., *Gypsophilla cerastioides* D. Don., *Geranium wallichianum* Sw., *Gerbera lanuginosa* Benth., *Galium sp.*, *Indigocra* sp., *Iris nepalensis* D. Don., *Justicia simplex* D. Don., *Leucas aspera* Spreng. *Lindenbergia urticifolia* Lehm. *Micromeria biflora* Benth., *Nepeta* sp., *Polygonum* sp., *Plectranthus* sp., *Pimpinella* sp., *Plantago major* Linn., *Ranunculus* sp., *Rhynchosia* sp., *Sonchus* sp., *Siegesbeckia orientalis* Linn., *Salvia* sp., *Scutellaria* sp., *Stachys* sp., *Valleriana wallichii* DC.

Common climbers are *Rubus lasiocarpus* Sm., *Rubus ellipticus* Sm., *Clematis monatana* Ham., *Vitis himalayana* Brand., *Vitis divaricata* Wall , and *Rosa moschata* Mill.

There are various grasses present, some of the common being *Setaria glauca* Beauv., *Setaria verticillata* Beauv., *Setaria italica* Beauv., *Digitaria cruciata* Nees., *Miscanthus nepalensis* Hack., *Oplimenus undulataefolius* Beauv., *Andropogen nardus* Linn., *Kaelaria cristata* Loisel., *Pannisetum flacidum* Koen., *Spodiopogon quadrinervis*, *Pollenia mollis* Hack., *Apluda cristata* Hack., *Avena asper* Munro., *Eragrostis nigra* Nees., and *Festuca gigantea* Vill. etc.,

Ferns that are commonly found along the road sides are *Adiantum venustum, Cheilanthes dalhousiae, Onychium muttisectum, Pteris excelsa, Ceropteris thalactroides. Asplenium unilaterale, Aspidium obliqum, Aspidum falcatum, Nephrodium aristatum, Polypodium auriculatum, Polypodium membranaceum,* and *Botrychium ternatum.*

VEGETATION ON CULTIVATED AND ABANDONED FIELDS

The cultivated fields are invaded by a number of plants referred to as weeds. Most of these are annual and occur in large numbers or in such close proximity with the cultivated crop that they cannot all be destroyed, therefore a plentiful seed supply for the ensuing year is nearly always assured. The most common plants that are found are *Amaranthus viridis* Linn. *Ipomea hederacea* Jacq. *Lactusa* sp. and *Polygonum* sp.

A few tilled fields have been abandoned and left due to the top soil being washed away. The dominant plants that are found here are *Urtica parviflora* Roxb., *Gerardinia heterophylla* Dcne., *Achyranthes aspera* Linn., *Polygonum plebejum* Br., *Nicandra physalsoides* Gaertn., and *Datura fastuosa* Linn.

VEGETATION ON THE LAKE AND ITS BANK

The sides of the lake is wooded with *Populus ciliata* Wall., *Salix babylonica* Linn., *Castanopsis sp.*, *Aesculus indica* Hiern., and Acers. Near the lake are found species of Carex (*Carex nubigena* D. Don., *Carex remota* Linn.,) *Cyperus neveus Retz. Cyperus iria* Linn , *Polygonum alatum* Ham., *Polygonum sp.*, *Sonchus oleraceous* Linn., *Oenothera rosea* Sol., *Erigeron canadensis* Linn., *Erigeron alpinus* , *Erigeron linifoius* Willd., and *Rumex orientalis* Bernth. The flora around the lake is same as that of surronunding area.

Inside the lake the water is clogged with *Potamogeton pectinatus* Linn., *Potamogeton indieus* Roxb., *Potamogeton perfoliatus* Linn., *Naias major* Allioni., *Hydrilla*

verticillata Casp., and *Myriophyllm spicatum* Linn. In the shallow water of the lake *Polygonum amphibium* Linn. and *Polygonum lapathifolium* Linn. are commonly seen after the rains.

SUMMARY

1. Observation on the vegetation of Naini Tal are being presented in this paper.
2. The climate, geology and biotic factors have been described.
3. Vegetation has been classified into woodlands, uplands, roadsides, cultivated and abandoned field and the lake and its bank.
4. Each type of vegetation has been given together with its floristic composition.

ACKNOWLEDGEMENTS

The author is deeply indebted to Prof. K. S. Bhargava, Head of the Botany Department, Government College, Naini Tal for his kind help and encouragement, and to Dr. G. S. Puri, Regional Botanist, Botanical Survey of India, Poona for his suggestions and criticism.

REFERENCES

Bhargava, K. S., & R. K. Gupta, 1958, Seasonal Material for a Flora of Naini Tal, *The Agra University Journal of Research* (Science) 7 : 1-48.

Duthie, J. F., 1906, *Catalogue of the Plants of Kumaon and of the Adjacent Portions of Garhwal and Tibet* (London).

Hooker, J. D., 1872-1897, *The Flora of British India*, London. Vols. 7.

Jain, S. K., 1956, On a Botanical Trip to Naini Tal, *Indian For.* 82 : 22-38.

Osmaston, A. E., 1927, *A Forest Flora for Kumaon*, Allahabad.

OCCURRENCE OF *RETORTAMONAS BLATTAE* BISHOP, *ENDAMOEBA BLATTAE* BUTSCHLI AND *NYCTOTHERUS OVALIS* LEIDY IN THE INTESTINE OF *PERIPLANETA AMERICANA* LINN.*

By

NARSINGH NARAIN

[Received on 10th August, 1939]

INTRODUCTION

The intestinal protozoa of cockroach have been extensively studied in foreign countries, but literature reveals that little work has been carried out in India. Ghosh (1921) reported from Calcutta *Nyctotherus ovalis* Leidy and two *Balantidium* species from the mid gut of *Periplaneta americana*. Bhatia and Gulati (1927) also recorded from Lahore *N. ovalis* from *P. americana.*

In the present paper *Retortamonas blattae* Bishop, *Endamoeba blattae* Bütschli and *N. ovalis* Leidy have been recorded from the intestine of *P. americana.*

MATERIALS AND METHODS

Periplaneta americana were collected from dirty and dark places in various localities. Sometimes an entire colony, collected from a particular place, was found to be devoid of intestinal protozoan fauna. They were kept in the laboratory in glass jars and lived for about a fortnight. The protozoan fauna, however, went on diminishing, till on the last day they had none. This may be due to their not relishing the diet, they were forced to live on. The intestinal contents were examined in normal saline. Intra-vitam staining was done with very dilute solutions of methylene blue and neutral red. The smears were fixed in Schaudinn's fluid, corosive sublimate, osmium tetroxide and Champy's fluid and stained with iron-alum haematoxylin, Dobell's haematin (alcoholic) and Mayer's haemalum (in some cases counter stained with picro indigo carmine). Schaudinn's fluid as fixative and iron-alum haematoxylin as stain gave most successful results. Mayer's haemalum also proved to be a good stain.

OBSERVATIONS

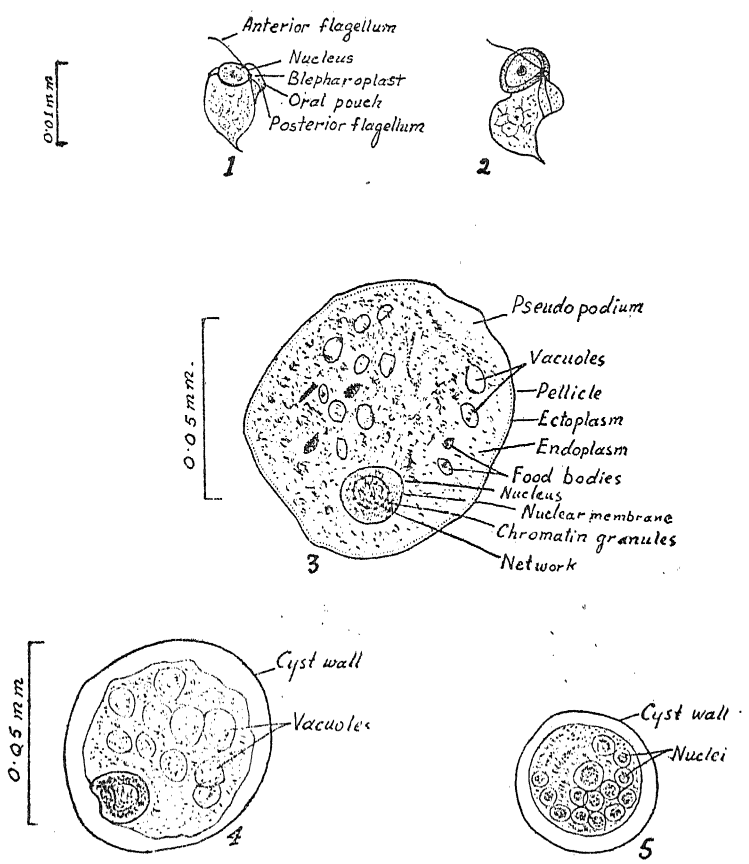
Retrortamonas blattae Bishop, 1931

R. blattae was first discovered by Bishop (1931) and later by Wenrich (1932) from the colon of *Blatta orientalis.*

General Description :

Living specimens are transparent and move swiftly in a zig-zag way. The body is somewhat fusiform, attaining roundedness in some cases. It is flexible,

* The present contribution is a part of the thesis, accepted for the degree of Doctor of Philosophy of the University of Lucknow.



Retortamonas blattae Bishop

Fig. 1. Front view, showing nucleus, flagella and origin of lips of oral pouch.

Fig. 2. Lateral view, showing large oral pouch and large nucleus.

Endamoeba blattae Bütschli

Fig. 3. An entire animal.

Fig. 4. A precystic stage.

Fig. 5. A cyst.

anterior end undergoes torsion and flexure, with the result that the widest part of the body is in the middle. Anterior end is rounded but posterior always pointed. The specimens measure 8 to 13 μ in length (including pointed posterior end) and 6 to 8 μ in width at the widest part of the body. On one side, below the nucleus, is oral pouch bounded by two lips. The anterior lip takes a darker stain than the posterior one, indicating some difference in the material of the two or in thickness. On the periphery of the nucleus are situated two closely lying blepharoplasts giving rise to two flagella. The posterior flagellum is shorter and is confined to the oral pouch. It is slightly thicker than the anterior one. Bishop (1931) found the posterior flagellum thinner than the anterior one. The anterior flagellum is longer, upwardly directed, helping in locomotion. It is only 1 or 2 μ shorter than the body length. The endoplasm is alveolar in structure and takes a light stain. Sometimes it is darker at some places, and this may be due to the presence of foreign bodies. The nucleus is at the anterior end, rounded or oval in shape. Immediately internally to the nuclear membrane on its periphery is darkly staining chromatin, providing a thick rim like appearance, In the centre of the nucleus is a darkly staining karyosom (figs. 1 & 2). The species described above closely resembles with *R. blattae* Bishop, although it is slightly larger in size. This is the first record of *R. blattae* from India.

Host and Locality :

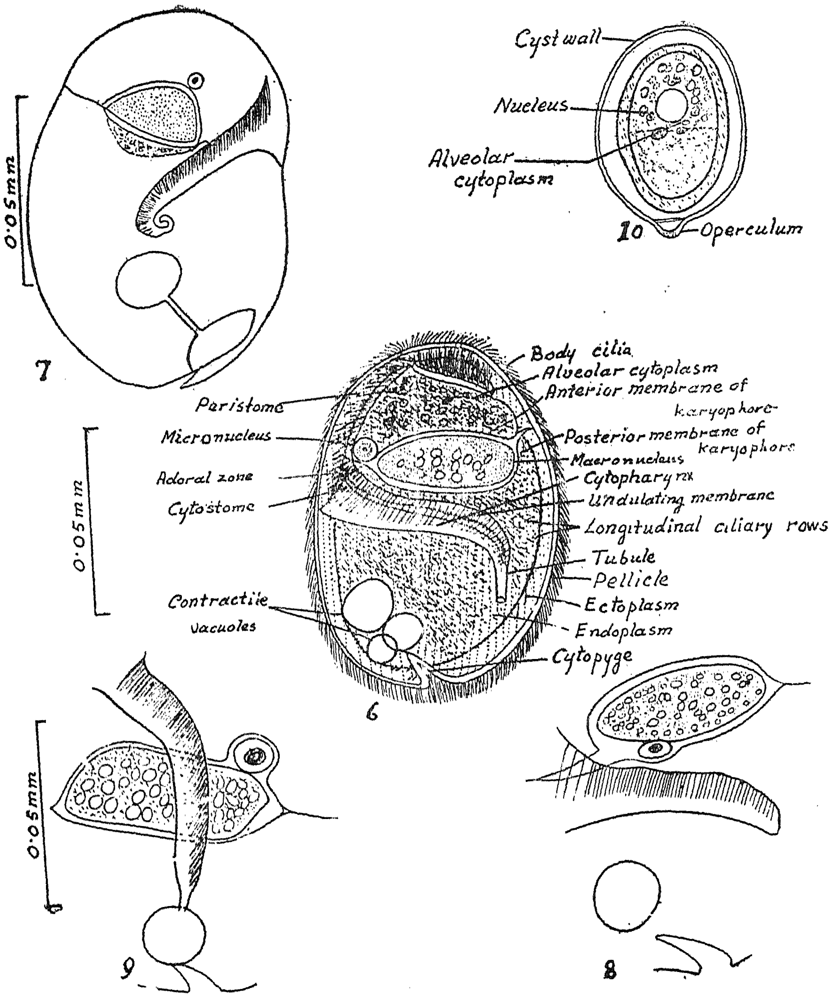
The forms were obtained from the intestine of *P. americana* Linn., collected at Badshahbagh, Lucknow and Jalaun, India.

ENDAMOEBA BLATTAE BÜTSCHLI, 1878

General Description :

E. blattae measure 34-80 μ in length and 32-73 μ in width. In living condition the pseudopodia are seen as one or two ectoplasmic blunt structures, transparent in nature. The nuclear structure is visible. Sometimes when the amoebae are moving, striations on the body are seen. The cytoplasm appears to be more vacuolated than in the stained preparations.

In fixed and stained specimens the body becomes rounded in shape. Clear transparent cytoplasm on the side opposite the nucleus represents pseudopodium. In a few specimens it is distinct and looks more or less spherical protruberance from the body. Pellicle is not so thick as in live ones. Ectoplasm is hardly 1 to 2 μ in thickness. The endoplasm is granular in nature having many vacuoles. These vacuoles are transparent and contain food particles and bacteria etc. Nucleus is always on one side of the body and shows typical generic character (figs. 3 and 4). Internal to the darkly staining nuclear membrane is a clear space all round. In the middle is fine reticular network. The area between this network and the transparent space is filled with darkly staining chromatin granules. These granules are very prominent on the outer part of reticular network. They are nearly rounded measuring 18 to 20 μ in diameter (fig. 3). Figure 4 represents a precystic stage measuring 58 x 53 μ. The outer cyst wall has just been secreted. The nucleus is on one side with a furrow appearing, network reduced and chromatin granules more prominent and increased in number. In some cases the network is very much reduced. The cyst wall is distinct and endoplasm has vacuoles in it. Figure 5 shows a fully formed cyst measuring 40 μ in diameter. The wall is darkly stained and the vacuoles and other food bodies



Nyctotherus ovalis Leidy

Fig. 6. An entire animal.

Fig. 7. An entire animal (outline sketch) to show shape of the body, nucleus and canal between two contractile vacuoles.

Fig. 8. Morphological type with micronucleus posterior and transverse cytopharyngeal posterior tube.

Fig. 9. Morphological type with micronucleus anterior and longitudinal cytopharyngeal tube.

Fig. 10. Cyst.

are not seen. The nuclei are from 12 to 22 µ and are seen at one side. The central area of a nucleus is darkly stained.

The present species was compared with the known species of the genus *Endamoeba*. It closely resembles *E. blattae* Bütschli (see Kudo, 1954). This is the first record of *E. blattae* from India.

HOST AND LOCALITY

The amoebae were obtained from the intestine of *P. americana* Linn., collected at Badshahbagh, Lucknow and Jalaun, India.

NYCTOTHERUS OVALIS LEIDY

General Description :

N. ovalis measure 90-130 µ in length and 65-80 µ in width. In my specimens the body is generally oval in shape (fig. 6), with both the ends rounded. Sometimes anterior end, which is somewhat compressed, is slightly tapering. This is seen often in small forms, which might be freshly excysted ones. Occasionally the body is found to be bean shaped (fig. 7).

The peristome, which starts at the anterior end of the body a little before the anterior extremity, turns towards right and ends into the cytostome. From cytostome a tubular structure called cytopharynx runs inside the body in transverse direction in most of the cases (figs. 6 and 8), but sometimes it becomes oblique or longitudinal (figs. 7 and 9). In good preparations cytopharynx is seen ending in a tubule, directed downwards (figs. 6 and 9), which is coiled antero-dorsally (fig. 7). This may be homologous to the "slender, band-formed structure" of *N. silvestrianus* Kirby (1932). On the anterior inner margin of cytopharynx are large cilia. Parallel to the wall of cytopharynx two or three fibres run transversely constituting the undulating membrane. It continues in the adoral zone as far as anterior region of the body. Longitudinal ciliary rows are present all over the body. On the sides, cilia measure 2 to 3 µ long. The pellicle is thick. The ectoplasm is thick and transparent, and its structure could not be made out due to the presence of rows of cilia. The endoplasm, in the anterior region of the nucleus, is alveolar in nature and transparent. It is of brownish colour and has a different refractive index. This may be due to the gathering of discoid glycogen bodies as stated by Kudo. The endoplasm posterior to the nucleus is darkly stained, granular in nature, containing some foreign inclusions. The cytopyge is terminal in position, formed by the invagination of ectoplasm. Contractile vacuole is large, single or multiple, the shape being rounded or oval (fig. 7). Sometimes a canal is seen between two contractile vacuoles (fig. 7).

The macronucleus is massive, oval or band like, extending from one end to the other in transverse position. It stains very darkly and in well differentiated forms shows spherical structures, some of them are very large. Kudo (1936) maintained that "the larger chromatin spherules of macronucleus of *N. ovalis* probably produce smaller spherules in their alveoli." This might be true because all sizes of spherules are present, the largest in my specimens being upto 10 µ. Macronucleus is attached to the side of the body with the anterior and the posterior membranes of karyophore. In *N. ovalis*, as stated by Zulueta and

Kudo, these fibrils are replaced by ectoplasmic membranes. Ten Kate (1927; 1928) studied fibrilar system in species of *Opalina*, *Nyctotherus* and other ciliates. According to him cytopharynx and nucleus are also connected with these fibrils. He suggested morphonemes for them, since he believed that the majority were form-retaining fibrils. Generally the micronucleus is spherical, but when pressed becomes oval. Mostly it is on the anterior part of the macro-nucleus, but positions may vary. It measures 4 to 6 μ in diameter and consists of nuclear membrane and a darkly staining central mass. It stains faintly in comparison to macronucleus.

Morphological types :

Based on the structure of the karyophore, its frontal lamina and the neuromotor apparatus attached to the cytopharynx De Mello (1934) and other workers recognised three morphological types : (A) Those with micronucleus separate from macronucleus, and anal groove simple, (B) those with micronucleus embedded in the mass of macronucleus, anal groove with one border protruded into a nipple-like point and (C) a transitional type with nuclear apparatus as in (A) and anal groove as in (B). Besides these types I have found, as shown in figures 8 and 9, two more types : (D) micronucleus posterior to the macronucleus (or below it), with simple anal groove and transverse cytopharyngeal tube and (E) micronucleus separate and anterior to macronucleus and longitudinal cytopharyngeal tube opening into contractile vacuole.

Cysts :

They are 50 to 60 μ long and 40 to 45 μ wide. Operculum is present on one side. The outer cyst wall is tougher than the inner cyst wall and is more darkly stainable. Interiorly in half of the cyst (away from operculum) there are alveolar structures probably representing glycogen. A nucleus is also present. The rest of the inner area is transparent, particularly in the middle, and this may represent future cytopharynx and peristome as stated by Lucas (1928).

The species described above appears at the first glance, to bear some contrasts with *N. ovalis* Leidy. A careful examination reveals that all the differences are only minor morphological ones. Their internal organization are indentical. In the present account some new details, not worked out so far, have been added.

HOST AND LOCALITY

The ciliates were obtained from the intestine of *P. americana* Linn., collected at Badshahbagh, Lucknow and Jalaun, India and **Gryllotalpa africana* Beauvois, collected at River-banks, Lucknow, India.

SUMMARY

The occurrence of *Retortamonas blattae* Bishop, *Endamoeba blattae* Bütschli and *Nyctotherus ovalis* Leidy in the intestine of *Periplaneta americana* Linn., has been recorded. The host insects were collected at Lucknow and Jalaun, India. The former two species have been reported for the first time from India. Some new details, not worked out so far, have been given in the description of *N. ovalis* Leidy.

* *N. ovalis* recovered from the intestine of *G. africana*, are identical with those obtained from *P. americana* ; the only difference is that the former is slightly smaller in size.

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REFERENCES

Armer, J. M., (1944), Influence of the diet of Blattidae on some of their intestinal protozoa, *Jour. Parasitol.* **30**, (3), 131-42.

Balch, H. E., (1932), Cultivation of Nyctoherus ovalis and Endamoeba blattae. *Science*, **76**, (1967), 237.

Bhatia, B. L. (1936), The Fauna of British India, Protozoa ; Ciliophora, Taylor & Francis Ltd., London.

Bhatia, B. L. & Gulati, A. N., (1927), On some parasitic ciliates from Indian frogs, toads, earth worms & cockroaches, *Arch. Protistenk.* **57**, 85-118.

Bishop, A., (1931), A description of Embadomonas n. sp. from Blatta orientalis, Rana temporaria, Bufo vulgaris. Salamandra maculosa ; with a note upon the "cyst" of Trichomonas batrachorum, *Parasitol.* **23**, 286-300.

Bütschli, O. (1878), Beiträge Zur Kenntnis der Flagellaten und einiger verwandten organismen, I. *Zeitschr. f. Wiss. Zool.*, **30**, 205-81.

———(1882-9), Protozoa. In Bronn, Klassen und Ordnungen des Tierreichs, Bd. *I.* & Bd. *III.*

Calkins, G. N. (1933), Biology of the Protozoa, 2nd edition. Philadelphia and New York.

Chen, L., (1933), Züchtungs versuche an parasitischen protozoen von Periplaneta orientalis (Endamoeba blattae, Nyctotherus ovalis, Lophomonas blattarum), *Z. Parasitenk.* **6**, 207-19.

Claparède & Lachmann, (1958-61), Etudes sur les infusorires et les rhizopodes, Genvèe (Extrait des toms *V*, *VI* et *VII* des *Mémoires* de *l'insitut Genevois).*

Cleveland, *L. R.* (1925), Toxity of oxygen for protozoa in vivo and in vitro. animals defaunated without injury, *Boil. Bull.*, **48**, 455-68.

Corradetti, A., (1937), Studio dei flagellati intestinali del Gryllotalpa gryllotalpa in rapporto all 'identita' del genere Embadomonas Mackinnon, 1911 col genere Retortamonas Grassi, 1879, *Riv. Parasitola.*, **I**, (1), 69-80.

Dobell, C., (1938), Researches on the intestinal protozoa of monkeys and man, IX. *Parasitol.*, **30**, 195-238.

Elmassian, M., (1909), Sur l'Amoeba blattae, *Arch. Protistenk.*, **16**, 143.

Froilano, De Mello, Carvalho, J. L. & Gaitonodo. P., (1934), Cytological studies on Nyctotherus ovalis, with special reference to its morphological types, *Proc. Ind. Acad. Sci.* 1, 249-57.

Ghosh, E., (1921), Infusoria from the environment of Calcutta, I., *Bull. Carmichael Med. Coll.*, **2**, 6-17.

Grassi, B., (1881), Intorno ad adcuni protistis endoparassitici edappartenenti alle classi dei Flagellati, Lobosi, Sporozoa et Ciliati, *Atti. della Soc. Ital. di Sci. Nat.*, **24**, 135-224.

————(1882), Sur quelques protistes endoparasites appartenant aux classes des Flagellata, Lobosa, Sporozoa et Ciliata, *Arch. Ital. Biol.*, **2**, 402-44.

Hall, R. P., (1953), Protozoology, Prentice-Hall, Inc. New York.

Hickson, J., (1903), "The Infusoria or corticate Hetrokaryota," in Lankester, *'Treatise on Zoology*, I. sec. 2.

Kent, W. S. (1880-82), A manual of the Infusoria, (London).

Kidder, G. W., (1937), The intestinal protozoa of the woodfeeding roach Panesthia, *Parasitol*, **29**, (2), 163-205.

Kirby, H., (1945), Entamoeba coli versus Endamoeba coli, *Jour. Parasitol.* **31**, 177.

Kudo, R. R., (1922), The parasitic protozoa of Blatta orientalis and their value as the material for use in class of parasitic protozoa, *Anat. Rec.* **23**, 113.

————(1926), Observations on Endamoeba blattae, *Amer. Jour. Hyg.*, **6**, (1), 139-52.

————(1936), Studies on Nyctotherus ovalis Leidy with special reference to its nuclear structure, *Arch. Protistenk*, **87**, 10.

————(1954), Protozoology, 4th edition, Charles C Thomas, Illinois. U. S. A.

Leidy, J., (1850), Two new species of Infusorial Entozoa, *Proc. Acad. Nat. Sci. Philad.* **5**, 100.

Lepsi, (1926), Die infusorien des Siiss Wassers und Meeres, Berlin, 1-100.

Lucas, C. L. T., (1927), Two new species of Amoeba found in cockroaches, with notes on the cysts of Ncytotherus ovalis Leidy, *Parasitol*, **19**, (2), 223-35.

————(1928), A study of excystation in Nyctotherus ovalis with notes on other intestinal protozoa of the cockroach, *Jour. Parasitol.*, **14**, (3), 161-76.

Mackinnon, D. L, (1915), Studies on parasitic protozoa. III. Notes on the flagellate Embadomonas, *Quart. Jour. Milrosc. Sci.*, **61**, 105-18.

Margaret, W. J., (1956), The Protozoa, Sarcodina, Oliver and Boyd, Edinburgh, London.

Mercier, L. (1907), Un parasite du noyau d'Amoeba blattae Bütschli, *Compt Rend. Soc. Biol.*, Paris, **62**, 1132.

————(1908), La schizogonie. simple chez Amoeba blattae Bütschli, *C, R. Acad. Sci.* Paris **46**, 18.

Mercier, L. (1909), Le cycle evolutif d'Amoeba blattae Bütschli, *Arch. Protistenk.* **16**, 165.

————(1910), Contribution a l'etude de l'amibe de la blattae (Entamoeba blattae Bütschli), *Ibid.*, **20**, (2), 143-75.

Minchin, E. A., (1922), *An introduction to the study of the Protozoa.* Edward Arnold, London.

Morris, S., (1936), Studies on Endamoeba blattae, *Jour. Morphol.* **59**, (2), 225-63.

Opinion rendered by the International Commission on Zoological Nomenclature, (1928), Opinions 98-104, *Smithsonian Misc. Coll.*, **73**, (5), 4-8.

————(1954), Opinion No., 312.

Pai, Kuo-Tung, (1948), The variations of Nyctotherus ovalis Leidy and its fibrillar system, *Sinesia*, **18**, (1/6), 43-58.

Sassuchin, D. N., (1928), Parasiten von Nyctotherus ovalis Leidy, *Arch. Protistenk.*, **64**, 61-70.

Semans, F. M., (1943), IV, Classified list of the protozoan parasites of the Orthoptera of the world. Class Mastigophora, Sarcodina, and Sporozoa, *Ohio Jour. Sci.*, **43**, (5), 221-34 & **43**, (6), 271-76.

Stein, F., (1867), II, (Allgemeines U. Heterotricha) *Leipzig.*, 344-47.

Stiles, C. V., (1902), The type species of certain genera of parastic flagellates, particularly Grassi's genera of 1879 & 1881, *Zool. Anz.*, **25**, 689-95.

Tenkate, C. G. B., (1927), Uber das Fibrillen system der ciliaten, *Arch, Protistenk.* **57**, 362-426.

Thomson, J. G. & Lucas, C. L. T., (1926), A preliminary note on the study of Endamoeba blattae (Bütschli 1878) Leidy 1879, found parasitic in the intestine of Blatta orientalis in England, with some remarks on its generic status, *Jour. Trop. Med.* and *Hyg.*, **29**, (3), 41-43.

Wenrich, D. H., (1932), The relation of the protozoan flagellate Retortamonas gryllotalpae (Grassi 1879), Stiles 1902 to species of the genus Embadomonas Mackinnon, 1911, *Trans., Amer. Microsc. Soc.* **51**, 225-38.

Wenyon, C. M., (1926), Protozoology. 2 vols. London & Baltimore.

Yakimoff, W. L. et Miller, G. A., (1922), Les Protozoaires de l' intestin de l' homme en de hors de l' organisme de l' homme l' examen de l' intestin du Periplaneta orientalis, *Bull. Soc. Path. exot.* Paris, **15**, 8-11.

GREGARINE PARASITES FROM THE INTESTINE OF *PERIPLANETA AMERICANA LINN., GRYLLODES MELANOCEPHALUS SERV. AND G. SIGILLATUS WALK.**

By

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INTRODUCTION

The genus *Gregarina* was created by Dufour in 1828 and since then thirty-two species, belonging to this genus, have been described by various workers from the gut of Arthropods. The genus *Leidyana* was created by Watson (1915). At present three species of this genus are known.

In the present work *Gregarina blattarum* Siebold from *Periplanata americana* Linn., *G. oviceps* Diesing from *Gryllodes melanocephalus* Serv. and *Leidyana erratica* Crawley from *G. sigillatus* Walk, have been recorded.

MATERIAL AND METHODS

The common cockroaches, *P. americana* Linn. were collected from various localities in dark, shabby and dirty places. Sometimes the cockroaches collected from a place did not harbour any protozoan fauna. In addition to the gregarines, species of *Nyctotherus, Endamoeba* and *Retortamonas* were also present in intestine and colon. The infection of gregarines was rare and only a few specimens were obtained. Gregarines were present in 1 out of 100 host insects,

The crickets, *G. melanocephalus* Serv. were collected from fields and crevices and were found to harbour only gregarines in their intestine. The infection was heavy and atleast 50% of the insects, dissected, possessed these parasites.

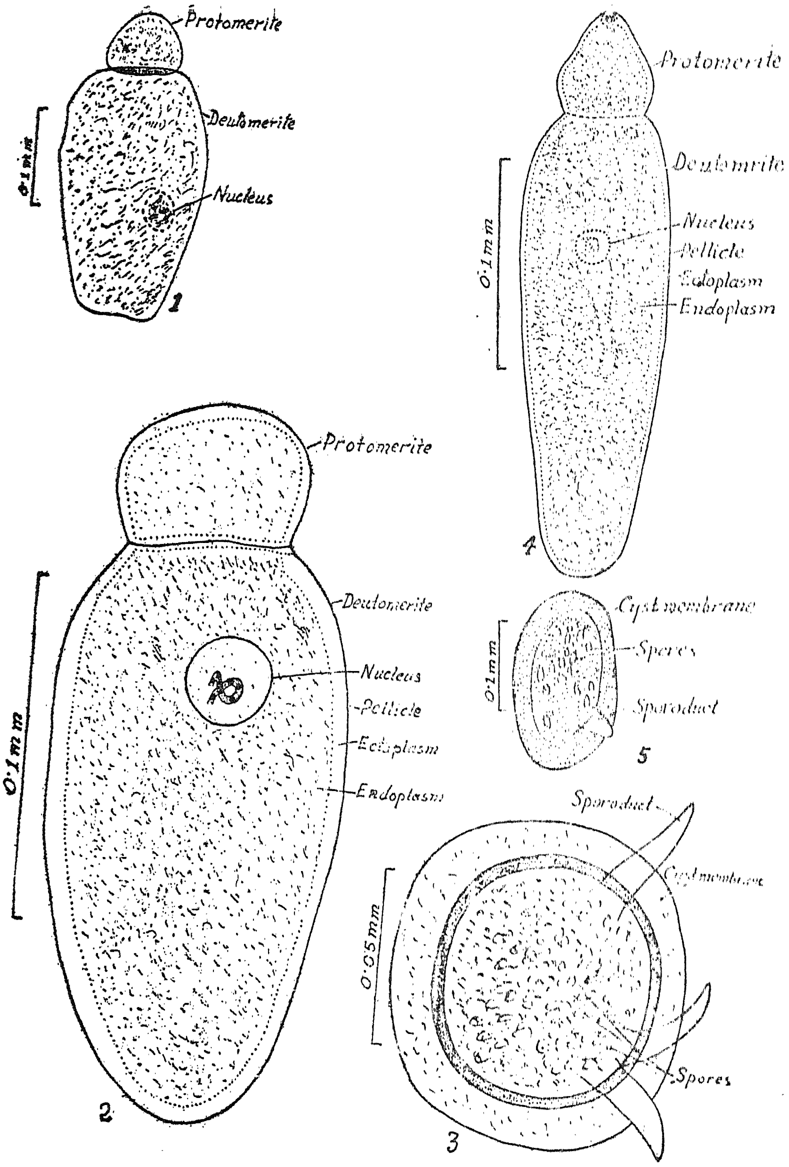
The house crickets *G. sigillatus* Walk were collected from the houses. They were found to be in abundance in corners and crevices of the kitchens of the College hall. Some of them were present in my room in the lower part of the almirah inside the waste papers. A few of them were collected from corners and crevices at Jalaun.

The parasites were observed in living condition in normal saline. The movements and body pigments, to some extent are helpful in the identification of the species.

The specimens were fixed in Schaudinn's fluid, Champy's fluid and 1% osmium tetroxide and stained with Mayer's haemalum (sometimes counterstained with picro-indigo carmine) and iron alum haematoxylin. Schaudinn's fluid with both the stains gave successful results.

Family Gregarinidae Labbé 1899

*The present work is a part of the thesis, accepted for the degree of Doctor of Philosophy of the University of Lucknow.



Gregarina blattarum Siebold

Fig. 1. An entire animal.

Gregarina oviceps Diesing

Fig. 2. An entire animal.

Fig. 3. Cyst.

Leidyana erratica Crawley

Fig. 4. An entire animal.

Fig. 5. Cyst.

OBSERVATIONS

Gregarina blattarum Siebold :

Siebold reported *G. blattarum* from the mid-gut of cockroaches, specially *Blatta orientalis*. The reproduction of this species has been described by Schiffmann (1919) and the chromosome cycle by Sprague (1941).

General description :

The parasites are 325-340μ in length and 143-152μ in width. In the living condition they are biassociative forming a small syzygy. They are thick and cylindrical in shape. Glycogenic food in deutomerite gives a pale appearance. The primite is slightly tapering towards both the ends of the body. The widest part is at the anterior 1/3rd of deutomerite. The ratio of the length and width of the body varies from 2·2 to 2·3. In the specimens studied, epimerite was not visible. In primite protomerite is triangular in shape, rounded at anterior end and measures about 60 μ in length and 90μ in width. In satellite the length is 40 to 50 μ and width about 100 μ. In the latter, there is a concavity at anterior end, the general surface is flattened. The contents are homogeneous. At the base is a thick septum. Deutomerite is nearly five times the length of the protomerite. The primite and satellite are cylindrical in shape. The posterior end is more rounded in satellite. Contents stain deeply in comparison to those of protomerite. Nucleus is rounded in shape, occupying in some cases anterior and in others posterior position. (fig.1)

The species described differs to some extent from *G. blattarum* Siebold only in the size of the body (see Kudo, 1954). No cysts or spores could be found. This is the first record of a *Gregarina sp.* from *P. americana* from India.

HOST AND LOCALITY :

The parasites were obtained from the intestine of *P. americana* Linn., collected at Badshahbagh, Lucknow, India.

GREGARINA OVICEPS DIESING, 1859

General description :

Sporadins are associated in two. Syzygy of upto six gregarines attached together was observed in living condition.

The parasites measure 195-276 μ in length and 95-160 μ in width at the widest part of the body. The body is stout, the satellite slightly smaller than the primite. The shape is sometimes oval, sometimes elongated as shown in fig. 2. Posterior end of the body is always rounded, looking like the pointed end of an egg. Size given by Watson (1916) is upto 500 $\times$ 250 μ; forms examined by Bhatia and Setna (1924) were shorter and narrower. Ratio of length and width of the body is from 1·7 to 2·0, though in some it is 1·4. Epimerite was not observed in any of the forms. The length of protomerite is 40 to 78 μ and width 60 to 95 μ. The ratio of the length of protomerite to total length of primite is from 1:4 to 1:5. Watson (1916) found this ratio to be 1:3 and Bhatia and Setna (1924) as 1:4 to 1:5·3. Ratio of the width of protomerite to the width of deutomerite is 1:1·5 to 1:1·7. According to

Watson (1916) it is 1:11. In satellite protomerite is somewhat longer and in primite flat and much wider and looks hemispherical to subglobose. The ratio between the length and width of protomerite is from 1:1·2 to 1:1·5. The contents are transparent in nature. Deutomerite is stout, the ratio of its width to the length being 1:1·2 to 1:1·8. Its width is always more than that of protomerite. A distinct septum is present between deutomerite and protomerite. The outer wall stains darkly and ectoplasm is transparent. The inner contents take a dark stain. Nucleus is sometimes spherical, sometimes oval in shape. It is about 35 μ in diameter, having a clear nuclear membrane and chromosome coiled inside. The shape of single chromosome is like 'S' in some forms. Cysts are spherical, about 95 μ in diameter. The cyst membrane is transparent and is about 10 μ thick. It is followed by a darkly stained layer nearly 2 μ thick. Inside this spores and nuclei are present. Three to four sporoducts have been found. In fig. 3 probably spore formation has not advanced and hence the sporoducts are small measuring upto 40 μ.

The species here described is somewhat shorter in size than *G. oviceps* Diesing as was also reported by Bhatia ana Setna (1924) from India. The cyst is also smaller. Syzygy of upto six gregarines was observed. At first glance this species looks like *G. rigida* Hall, but differs from that in having less number of sporoducts and no epimerite.

Host and Locality :

The specimens were obtained from the intestine of *Gryllodes melanocephalus* Serv., collected at Badshahbagh, Lucknow, India.

LEIDYANA ERRATICA CRAWLEY

General description :

In the living condition the specimens are flat or slightly cylindrical moving parallel to the surface. The protomerite is transparent but deutomerite contains some blackish brown pigments. Sporadins are solitary, with anterior end slightly pointed and posterior always rounded. The widest part of the body is a little away from the junction of protomerite and deutomerite. The gregarines measure 260 μ to 295 μ in length, and 70 μ to 85 μ in width. The ratio is nearly 3·6. Watson (1916) found maximum length and width to be 500 × 160 μ. Epimerite is represented by a black spot like structure at the anterior tip. Protomerite at the anterior end is narrow amd tapering but still rounded. Slightly posterior to its mid part are two lateral expansions, narrowing posteriorly to a point, where the septum is present. Only the posterior part of protomerite takes stain. It is about 48 μ long and 48 μ wide at the expanded part and ratio to the whole body is 1:5. Deutomerite is nearly four times as large as the protomerite. The pellicle stains darkly and ectoplasm is more or less transparent. The contents of the deutomerite are stained deeply. Nucleus is in the anterior half of the body measuring 10 to 12 μ in diameter (fig. 4). The cysts are oval and are 195 × 120 μ in dimensions. The outer cyst membrane is thick, measuring 20 to 25 μ. The spores are present inside the cyst. Only one sporoduct could be seen. (fig. 5).

The present species looks more like *L. erratica* (Crawley) though the size is much smaller. It bears no resemblances with the other two known species of the genus *Leidyana*.. This is the first record of *L. erratica* from India.

Host and Locality :

The protozoan parasites were found in the intestine of *G. sigillatus* Walk, collected at Badshahbagh, Lucknow and Jalaun, India.

SUMMARY

Three species of gregarines, namely, *Gregarine blattarum* Siebold from *Periplaneta americana* Linn., *G. oviceps* Diesing from *Gryllodes melanocephalus* Serv. and *Leidyana erratica* Crawley from *G. sigillatus* Walk, have been recorded. *G. blattarum* and *L. erratica* have been recorded for the first time from India.

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REFERENCES

Allegre, C. F., (1913), Contribution to the life-history of a gregarine parasitic in grasshoppers. *Trans. Amer. Microsc. Soc.*, **67**, (3) 211-26.

Armer, J. M., (1944), Influence of the diet of Blattidae on some of their intestinal protozoa. *Jour. Parasitol.* **30** (3): 131-42.

Bhatia, B. L., (1938), The Fauna of British India, protozoa: Sporozoa, Taylor & Francis Ltd. London.

Calkins, G. N., (1933), Biology of the protozoa. 2nd edition Philadelphia and New York.

Crawley, H., (1903), List of Polycystid gregarines of the United States. *Proc. Acad. Nat. Sci. Philadelphia.* **55**: 41-58.

———— (1907), The Polycystid gregarines of United States (third contribution). *Ibid.* **59**: 220-28.

Dufour, L., (1928), Note sur la grégarine, nouveau genre de ver qui vit en troupeau dans les intestins de divers insects. *Ann. Sci. Nat.* **13**: 366-9.

Ellis, M. M., (1913), A descriptive list of the Cephaline gregarines of the new world. *Trans. Amer. Microsc. Soc.*, **32**: 259-96.

Hall, M. C., (1907), A study of some gregarines with special reference to Hirmocystis rigida n. sp. *Univ. Studies (Lincoln, Neb.)* **7**: 149-74.

Hall, R. P., (1953), Protozoology. Prentice-Hall, Inc. New york.

Harrison, A. D., (1955), Four new species of gregarines from mountain cockroaches of the Cape Penninsula. *Ann. S. African Mus.* **41** (6) : 387-405.

Kamm, M. W., (1922), A list of the new gregarines described from 1911 to 1920. *Trans. Amer. Microsc. Soc.* **41**: 122.

Kado, R. R., (1954), Protozoology. 4th edition, Charles C Thomas, Illinois. U. S. A.

Labbé, A., (1899), Sporozoa. In Das Tierreich, part 5.

Leger, L., (1892), Recherches sur les grégarines. *Tabl. Zool.* **3**: 1.

Leidy, J., (1853), On the organization of the genus Gregarina of Dufour. *Trans. Amer. Philos. Soc.*, (n. s.) **10**: 233.

Minchin, E. A., (1922), An introduction to the study of the Protozoa. Edward Arnold, London.

Schneider, A., (1875), Contributions àl' histoire des grègarines des invertóbrós de Paris et de Roscoff. *Arch. Zool. Exp.* et *Gen.* **4**: 493-604.

Semans, F. M., (1943), IV. Classified list of the protozoan parasites of the Orthoptera of the world. Class Mastigophora, Sarcodina & Sporozoa. *Ohio Jour. Sci.* **43** (5): 221-34 and **43** (6): 271-76.

Siebold, C. T. Von (1839) Beiträge zur Naturgeschichte der Wirbellosen Thiere. Ueber Medusa, Cyclops, Loligo, Gregarina und xenos. *Neueste Schrift.* d. *Naturf. Ges. Danzig.* 3.

Sprague, V., (1941) Studies on Gregarina blattarum with particular reference to the chromosome cycle. *Illinois Biol. Monogr.* **18**: (2).

Stein, F., (1848) Üeber die Natur der Gregarinen. *Arch. Anat. Phys. Wiss. Med.* 182-223.

Watson, M. E., (1915) Some new gregarine parasites from Arthropoda. *Jour. Parasitol.* **2**: 27-36.

————— (1916) Observations on Polycystid gregarines from Arthropoda. *Ibid.* **3**: 65-75.

————— (1916) Studies on gregarines. *Illinois Biol. Monogr.* **2** & 3: 211-468.

————— (1945), A new sporozoon, Gregarina rhyparobiae n. sp. from a tropical cockroach, Rhyparobia maderae. *Parasitol.* **36** (3/4): 195-98.

Wenyon, C. M, (1926) Protozoology. 2 vols. London & Baltimore.

ON THE STING APPARATUS OF POLISTES

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INTRODUCTION

The present paper presents an account of the sting apparatus of *Polistes*. The complicated sting apparatus is a modified form of simple ovipositor. Works of Nelson (1918), Crampton (1919) and Snodgrass (1930-33) elucidated the true nature of the sting apparatus in honeybee and certain other Hymenoptera. According to the views of Snodgrass, only higher members of Hymenoptera such as bees and wasps, possess true sting, which in the lower forms, is represented by the ovipositor.

MATERIAL AND TECHNIQUE

The adult wasps on wings were caught by nets and killed in cyanide bottles Dissections were performed under a binocular microscope under normal saline soon after killing. The dissected material was stained in haematoxylin-eosin or borax carmine, which stained the soft parts nicely. Dehydration was done in the usual way and the material was mounted in balsam.

OBSERVATIONS

The sting (st.) represents the female ovipositor which is structually changed and adapted for carrying out the entirely different function of stinging. It no longer takes part in the process of egg-laying. It can be protruded or retracted by the action of the muscles.

The portion of the sting which is generally seen projecting at the terminal end is a sheath (Pls. I, Fig. I, Sh.) which protects and encloses two triangular needles, the *lancets* (let.). The sheath may be called the director and in wasps it penetrates into the body of the victim by means of an extremely powerful muscle inserted on a special tri-radiate sclerite (*Tri. Sc.*). The two arms of this sclerite articulate with two facets one on each side of the base of the sheath. The two sets of muscles arising from the base of the inner surface of the second valvifer or the oblong plate (pl. I, Fig. I, ob. pl.) work the director. The points of articulation between the arms of this small sclerite and the groove in the sheath (*fc*), act as fulcra. The act of piercing the sheath into the victim is the direct result of the contraction of a pair of muscles (*Add Sh.*). These originate from the inner anterior surface of the second valvifer, and are inserted of the two arms of the triradiate sclerite. As a result of the contraction of this muscle, the arms are pulled posteriorly carrying the sheath in the same direction. This would naturally force the sheath into the victim's body. A few bundles of this muscle run in between the apodeme of the valvulae (*vl.*) and the distal end of the arms of the triradiate sclerite. The insertion of these muscles on the arms of the triradiate sclerite is extremely interesting. The more anterior is the origin of the fibres, the more dorsal is their insertion, hence those inserted on distal ends originate most posteriorly from the base of the valvifer. To the dorso-laterally compressed ridge of this sclerite

is inserted laterally a pair of muscle, (*Ret. Sh.*) (one on each side) which arises from that portion of the inner margin of the second valvifer which lies just ventral to it. Hence their contraction pulls the dorso-laterally compressed ridge closer to the sheath resulting in an anterior movement of the whole apparatus. That is how the sting is withdrawn from the victim's body. The muscle in question is extremely powerful and the sclerite highly chitinous, which leaves no possibility of the sting being detached from the insect unlike honey bee.

The director or the sheath is sharply pointed posteriorly. The upper surface is cylinderically round and the lower one has a deep groove. The whole structure appears to be a conical cylinder with a slit running longitudinally all round its length. The two dorsally diverging curved arms at the posterior end connect the sheath to the second valvifer. The edges of the ventral groove of the director are inwardly curved (pl. I, Figs. 5, *Cm. sh.*) and they form long slots along which the outer ridge of the lancet comes to lie. The posterior portions of the lancets or needles also possess a groove (fig. 4) to fit over the slot, and can, therefore, freely slide over it in anterior and posterior directions. The arrangement of articulation is so efficient that the needles can not be separated from the sheath quite easily. The lancets are long and they curve dorsally at the posterior end running in close proximity with the arm of the sheath. Like the director they also meet a traingular plate, the 1st valvifer which posteriorly articulates with the quadrate plate. At the posterior end the director is enlarged and its groove is widened ; the needles become free from the inturned margins of the sheath and immediately afterwards they curve dorsally and outwardly. The needles are almost four sided and are hollow each bearing canal for the passage of poison (pl. I, Fig. 5, *Lct.* The canals are gradually changed into furrows at the posterior ends. These furrows of both the needles, facing each other, form a canal at the posterior end when they come to lie adpressed to each other. At their posterior apices they are serrated and acuminate with six teeth (fig. 3). Between the sharp band of the needles is interposed, a membranous sac, the female genital canal into which opens the vagina. A small traingular chitinous plate the first valvifer (vlf. 1) is found at the dorsal end of each needle. Over this plate are inserted two big muscles, one (*vlf. m* 1) arises from the outside of the quadrate plate and another (*vlf. m* 2) muscle from the inner surface of the quadrate. These operate in with-drawing the needles as well as the sheath. Another small muscle (*vlf. m* 3) originates on either side at the commencement of the curve of the needle and is inserted laterally on the base of the sheath. This muscle assists in with-drawing the sheath after injecting the poison. A huge muscle (*vlf. m* 4) originates from the inner sides of the quadrate plate and is inserted on the apodeme at the base of the sting palp, which is operated by this muscle.

Another small muscle runs between the base of the triangular plate - the first valvifer, and the anterior tip of the dorsal ridge of the tri-radiate plate (vlf. m 5).

The poison sac is highly muscular sac with muscles arranged on the outside in three separate bundles and with fibres running in various directions. This arrangement imparts very great compression of the sac. It is internally lined by a thin peritoneum of flat cells (pl. I, VII, Fig. I). A stout poison duct arises from the ventral side.

Another tubular compressed and somewhat convoluted gland also sends out its secretion by means of a small tube which meets the poison duct and opens with it. This is the alkaline gland and is supposed to neutralise the acidity of the poison remaining within the poison-sheath after stinging.

EXPLANATION TO PLATES

Plate I

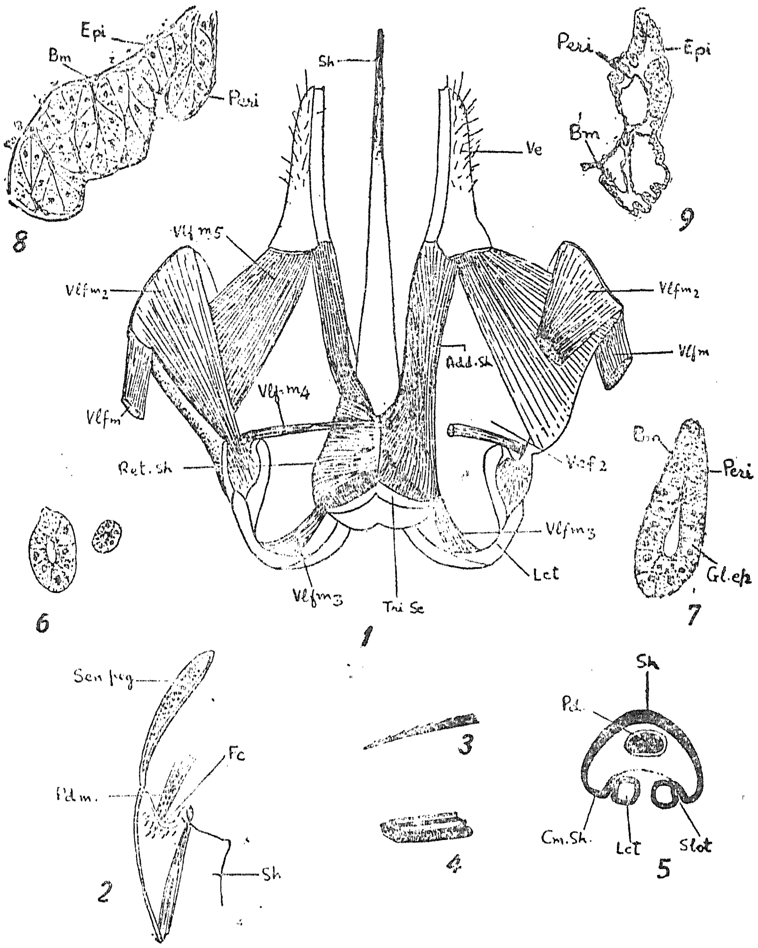

Fig. 1. A dorsal view of the musculature of female genitalia.
Fig. 2. The bulb of the sheath showing the articular facet for the tri-radiate plate and sensory pegs over the arm.
Fig. 3. The dentate tip of the lancet.
Fig. 4. A diagrammatic section of the middle portion of the lancet.
Fig. 5. A transverse section of the sting.
Fig. 6. A transverse section of the acid gland (under low power).
Fig. 7. A transverse section of the acid gland (under high power).
Fig. 8. A transverse section of the alkaline gland (under high power).
Fig. 9. A transverse section of the alkaline gland (under low power).

LETTERING

Add. Sh : muscles which protrude the sheath of the sting; Bm : basement membrane; Cm.Sh: curved margin of the sheath ; Fpi : epithelium of the mucous gland ; Fc : facets where tri-radiate sclerite articulates ; Gl. ep : glandular epithelium ; Lct : lancet , Peri : peritoneum ; Pd : poison duct ; Pdm : muscles of the poison duct : Ret Sh : muscles which draw in the sheath of the sting ; Sen. peg : sensory peg ; Sh : sheath ; Tri, Sc. : tri-radiate sclerite ; Ve : sting palpus or valvula ; Vef : second valvifer or oblong plate ; Vlfml-5 : muscles to operate the sheath and lancets.

The internal lining of the dilated portion is composed of columnar epithelial eells, which form a large number of villi. A thin basement membrane surrounds the gland all round followed by scattered fibres of longitudinal muscles.

A large number of peg-like small stout hairs are found growing on the outer side of the curved portion of the lancet and also on the anterior margin of the sheath where the tri-radiate plate articulates. (pl. I, Fig. 2, *sen peg.*). These are probably sensory in function.

The poison gland consists of two long thin and highly convoluted thread-like structures lying in the mass of the fact body on the right and left sides and are often mistaken for Malpighian tubules. Their terminals are comparatively thicker and glandular, while ends, meeting the poison sac, are extremely slender and difficult to detect. They open into the anterior end of the poison-sac from the posterior end of which, the poison duct takes it origin.

The alkaline gland is made up of large sized elongated cells; which line the whole cavity. Mostly there is only a single layer of cells. A thin peritoneum forms another coating.

In most other stinging insects the sting breaks in the victims' wound and they die as a result of the injury. In the wasp under study, the musculature is highly developed, hence the sheath with all the appurtenent structures is ultimately withdrawn from the victim. Thus, in this case the sting apparatus is not detached from the body and the animal does not die. It is, however, interesting to note that the wasps generally do not live if their stings are cut off artificially.

ACKNOWLEDGEMENTS

The work was planned and carried out in the laboratory of the Department of Zoology of Balwant Rajput College, Agra. The author is greatly indebted to Dr. L. P. Mathur, D.Sc., Registrar, Agra University for considerable advice and assistance.

REFERENCES

Crampton, G. C. 1919 : The genitalia and terminal abdominal structure of males and the terminal structure of the larvae of "Chalastrogastrous" *Hymenoptera*. *Proc. Ent. Soc., Washington*, **21**, 129-156.

Nelson, J. A., 1918 : The segmentation of the honey bee. *Ann. Ent. Soc. Amer.*, **11** : 1-8, 2 Fig. pl. I.

Snodgrass, R. E., 1931 : Morphology of Insect Abdomen, Part I. General Structure of the abdomen and its appendages. *Smith. Misc. Coll.*, **85** (6), 1-125.

———————1933 : Morphology of Insects Abdomen, Part II. The genital ducts and ovipositor. *Smith. Misc. Coll.*, **89** (8), 1-148.

ON THE RESPIRATORY SYSTEM OF POLISTES

By

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INTRODUCTION

Although the tracheal system of insects has been much studied, knowledge of its sturucture in wasps is scanty. The present investigation is an attempt to give a detailed morphological account of respiratory organs in *Polistes hebraeus*, the common yellow wasp.

MATERIAL AND METHODS

The wasps are captured on wings and killed in cyanide bottles before dissection. The tracheal system was studied in dissected specimens. The freshly killed insects were fixed on wax and were dissected under binocular dissecting microscope. Various established methods of studying the tracheal system were employed, but it was found that slightly warming the freshly killed specimens, before fixing on paraffin gives best results. The tracheal tubes and air-sacs appear white and glossy because of being distended with air.

OBSERVATIONS

The tracheae open outside the body by means of ten pairs of spiracles, two in the thorax, one in the propodaeum, and the rest in the abdomen. Internally the tracheae branch into many minute tracheoles, which penerate the tissues of the body.

The Spiracles. Out of the ten pairs of spiracles; enumarated above those of the thorax are hardly visible externally because they open in a special intersegmental chamber. The prododeal spiracles and the first two abdominal ones are prominently visible. The rest are hidden underneath the posterior free margin the of preceding segments and can be easily seen by slightly stretching the abdomen. The tenth spiracle cannot even then be seen in females as the eighth tergite, which locates it, lies concealed owing to the telson completely enveloping it.

They lie in a row on the sides of the body. The lateral margins of the terga of the abdomen are perforated by the spiracular apertures, while the thoracic spiracles open in the intersegmental membrane.

The first thoracic spiracles is situated a little anteroventral to the base of the first wing in a furrow in between the mes-epimeron and the mid-lateral process of the posterior margin of the prothoracic scutellum (pl. I, Fig. 1, *sp*. 1). It lies concealed underneath this flap which is slightly more chitinised forming an apodeme. The marginal apodeme has a branch running inwards (x. 16). Another apodeme runs for a short distance in between the marginal apodeme and its branch (pl. I, Fig. 5, x. 17).

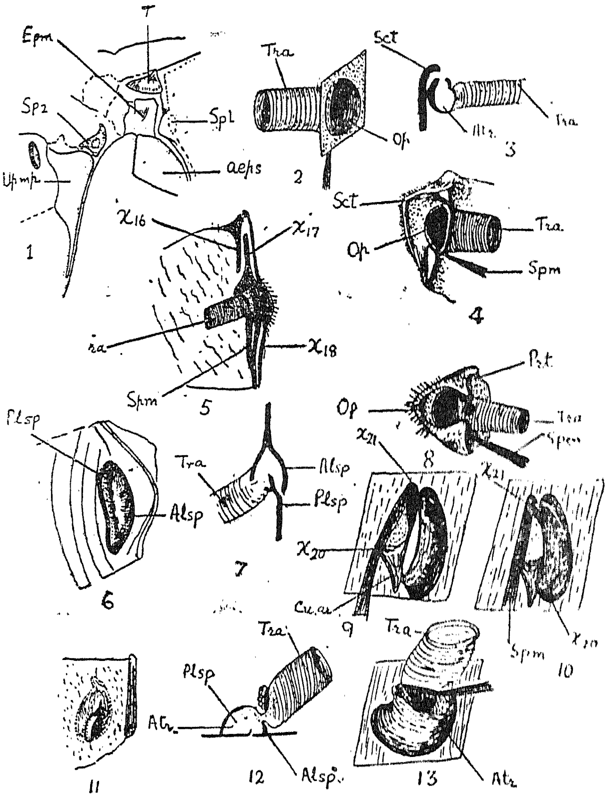

PLATE I

Fig. 1. A lateral view of the thoracic sclerite showing the location of first and second spiracle.

Fig. 2. A diagrammatic sketch of the first thoracic spiracles.

Fig. 3. A longitudinal section of the first thoracic spiracle.

Fig. 4. An inner view of the second thoracic spiracle.

Fig. 5. A diagrammatic sketch of the inner view of the first thoracic spiracle.

Fig. 6. A lateral view of the propodeal spiracle.

Fig. 7. A cross section of the propodeal spiracle.

Fig. 8. An inner view of the second thoracic spiracle.

Fig. 9. An inner view of the propodeal spiracle with the its musculature in an opened condition.

Fig. 10. An inner view of the closed propodeal spiracle.

Fig. 11. A lateral view of a typical abdominal spiracle.

Fig 12. A cross-section of the abdominal spiracle.

Fig. 13. An inner view of the abdominal spiracle.

An apodemal loop is thus formed in which the operculum and the trachae are lodged. On the ventral side, the marginal apodeme has again given out a small branch (x. 18) from which originates the spiracular muscle, (pl. I, Fig. 5, sp. m. 1). If the proeess is dissected out and removed a chitinons cresent shaped light brown operculum is seen (figs. 2, 3, & 4. op.) covering the opening of the spiracle. The operculum rests against the inner surface of the tergum and forms a sort of upper lip, while the lower lip is formed by a narrow and very slightly cuticular margin of the trachea. The operculum is worked by means of a tender spiracular muscle inserted on its outer margin which originates from the ventral branch of the marginal apodeme on the inner surface of the protergum. When it contracts, it presses the upper lip against the lower so as to close the opening of this spiracle which looks like a half closed slit. Slight change in the curvature of the posterior margins of the pro-scutellum affects the opening and closing down of the spiracular aperture. The atrium (fig. 3. *Atr.*) is membranous and into its anterior portion the tracheal trunk opens. The spiracle does not directly open outside but in a small chamber formed by the invagination of the intersegmental membrane. The chamber opens out in the furrow between the posterior margin of proscutellum and the mesepimeron. This spiracle is oval in shape with its longest diameter vertical. The position of the spiracle is clearly marked out owing to the absence of yellow pigment in this area.

The second spiracle lies in between the upper ends of the mesepisternum and the metapleuron (pl. I, Fig. 1, sp 2). It is situated on a special sclerite or peritreme, which *anteriorly* articulates with the subalar process of the mes-epimeron and posteriorly with the dorsal margin of the upper plate of the metapleuron. It thus comes to lie in between the bases of the fore and hind wings. The *Perilreme* (fig. 8. *prt.*) is a subtriangular small sclerite rounded at its posterior apex. The anterior margin is curved inwards and forms two ridges or apodemal processes (Fig. 8. x. 19) between which the operculum is hinged. The spiracle very closely resembles the first thoracic structurally. Here again the spiracle opens in a chamber of the inter-segmental membrane and the opening of the spiracle is concealed underneath the peritreme. The second spiracle is quite prominent and is slightly smaller than the first. It is not small and indistinct as in honey bees. Like the first spiracle a small muscle controls its opening.

Propodeal spiracles. It is the largest pair of spiracles (pl. I, Fig. 6.) over the body which lies exposed on the antero-lateral margin of the propodeum and looks like a compressed oval aperture. The anterior margin of the spiracle is raised into a lip (Fig. 6 Al. *sp.*) which covers its slit – like opening. The posteriar margin of the spiracle is raised externally and internally to form an external and internal lip respectively (Fig. 7, p. l. s. p. and II sp). The opening of the spiracle is closed by means of a valve which is controlled by a muscle. The valve possesses a cuticular arch (Figs. 9 & 10 *cu. ar.*) attached to the posterior lip. It fits over the spiracle and lies closely adpressed against the inner anterior lip and closes the spiracular aperture. The valve possesses a broad triangular darsal (x 20) and a smaller club-shaped ventral piece (x. 21), which are joined together by a narrow cuticular arch. A small muscle (*spm.*) which originates from the inner surface of the propodeum is inserted on the dorsal triangular sclerite of the valve and the same muscle is continued forward to the ventral club-shaped sclerite also. Hence any contraction of the muscle increases the curvature of the arch formed by two pieces of the valve and closes the spiracle : its relaxation on the other hand decreases the curvature and the spiracle is opened.

The abdominal spiracles are situated on the lateral sides of each tergum up to the eighth segment. The first six abdominal spiracles are visible on the surface

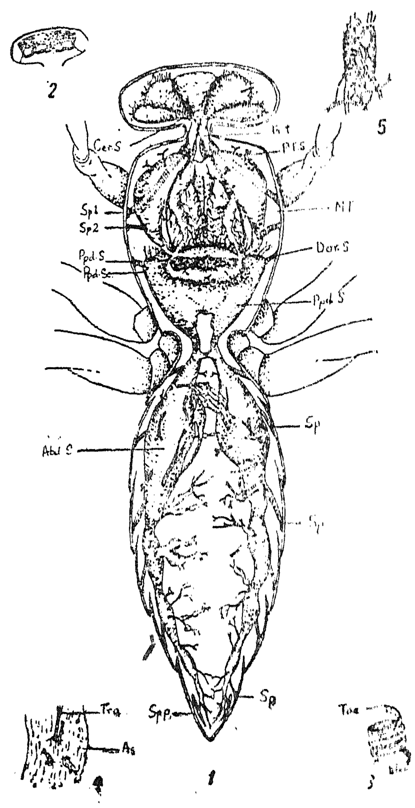

PLATE II

Fig. 1. A dorsal view of the tracheal system.

Fig. 2. The tracheation of the vertex.

Fig. 3. A trachea showing the taenidia.

Fig. 4. A portion of an air-sac with origin of trachea.

Fig. 5. The tracheation of the last abdominal ganglia.

LETTERING

Abd. S—abdominal air-sac; Aeps—anepisternum; Alsp—anterior tip of spiracle; As—air-sac; Atr—strium; Cer. S—cervical air-sac; Cu. ar—cuticular arch which closes the propodeal spiracle; Dor. S—dorsal air-sac; Epm—epimeron; Eps—episternum; Ms—mesoscutum; MT—metathorax; Op—operculum; Plp—posterior lip of the propodeal spiracle; Ppd. sac—propodeal air-sac; Ppd. Sp—propodeal spiracle; Prt—prothorax; P. T. S.—prothoracic spiracle; Sct—scutellum of prothorax; Sp—spiracle, Sp2—second spiracle; Spm—spiracular muscle; Spp—spiracular plate; Tae—Tracheal Taenidia; Tra—trachea; Tra. Spm—tracheo-spiracular muscle; Tr.t.—tracheal trunk; Upmp—upper plate of metapleuron; X 16—branch of the apodeme forming anteroelatral margin of proscutellum; X17—the apodeme of the first spiracle; X18—ventral apodeme of the first spiracle; X19—mapodemal process of the peritreme; X20—triangular piece of the cuticular arch which closes the preopodeal spiracle; X21—the club-shaped piece of the cuticular arch which closes the propodcal spiracle.

but the last pair on the eighth segment is concealed by the enveloping telson. All the abdominal spiracles have narrow slit-like openings with the anterior margin slightly covering the posterior (pl. I, Fig. 11). This opening leads to a chamber (*atr.*) having chitinous walls and membranous bottom from which a tracheal tube originates. The posterior wall is very high and forms a large portion of the chamber; the anterior is simply like a ridge where the membranous portion of the chamber is attached and it looks like an outer lip (fig. 12). The outline of the chamber can be easily seen through the transparent body wall. The abdominal spiracle resembles the propodeal spiracle closely in structure. The opening of the trachea into this chamber is guarded by a two-piece- valve as in the propodeal spiracle. A similar muscle attachment opens and closes the opening of the trachea to allow or disallow communication between the atrium and the cavity of the trachea.

Tracheae. The body of the wasp is full of air sacs and tracheal tubes. These extend throughout the length of the insect on both sides and receive numerous branches from the various organs, body wall and the spiracles. The air sacs are interconnected by means of transverse vessels dorsally as well as ventrally. In each segment there is generally a large air sac or a dilated portion of the tracheal tube with minor sacs, which supply the neighbouring organs. The tracheae divide and sub-divide into very minute tracheoles and enter the cells of the tissues. From each of the thoracic segments large tracheal trunks lead to the legs and to the wings. In the head, branches of trachae supply the eyes, antennae and various mouth parts.

The trachea of the wasp (pl. II, Fig. 3) is a very thin walled branching tube which is thickened by means of chitinous bands, wound spirally within the tracheal cavity. Two taenidia (Fig. 3, *Tal.*) form the spiral in an anti-clock wise direction. This spiral is covered over by means of a transparent membrane of epithelial cells and lined by an exteremely delicate intima which sometimes shows a lightly striated appearance. The trachae are slightly flexible and do not collapse. The air sacs are made up of thin transparent silvery white highly elastic membrane (Fig. 4). When expanded an air sac acquires an enormous size but it is reduced to a small sac in the collapsed condition. There are no taenidia present in the air sacs. The inner wall is also often seen to possess folds of intima. The air sacs may be, therefore, considered as expanded trachae without the taenidia. They vary in size from very small vesicles to huge bags. The constant expansion and contraction of the abdomen brings about a change in the volume of these air-sacs and also in the pressure within them. This change brings about respiration.

Air sacs. There is a heavily branched system of air-sacs with very thin and distensible walls. Minute branches from these pass through the muscle bundles and salivary glands making the whole system extremely complicated. Two large thick tracheal trunks (pl. II, Fig. 1, *Trt*) enter the neck and head from the antero-lateral side of the prothorax, and lie in between the dorsal and ventral portions of the large prothoracic sacs. These tracheal trunks join in the cervical region and form a cervical sac (*Cer. S*). Posteriorly each of them bifurcates, one branch runs along the antero-lateral side through the salivary gland and leads to the first spiracle; the other, which is comparatively a smaller branch, joins the prothrocic sac. The two prothoracic sacs (fig. 1, *P. T. S.*) also meet masially in a small dialatation and many minute tracheal tubes are given off from this junction, which traverse posteriorly underneath the longitudinal muscles and are lost in the meso-thorax. A very minute long trahea also runs in the middle line and passes through the salivary glands. A branch from each of the prothoracic sacs joins a median transverse

dorsal sac (*Dor. S*) lying under the meso and meta-thoracic tergites. From the ventral portion of the pro-thoracic air sacs; branches are sent to the front legs, muscles, oesophagus, etc., and also a pair of small branches to the second thoracic spiracles. These sacs are further continued laterally into a large propodeal sac which occupies the whole of the propodeum and lies under the postscutellar plate.

The transverse sacs lie under the mesoscutellum and one in the mesonotum which opens laterally into the big ventral propodeal air sac.

The cervical sac is continued into a frontal sac, a pair of mandibulars and a labial. A large sac also lies under the vertex.

From the propodeal sac a pair of prominent tracheal tubes arise which pass through the petiole and meet a pair of huge tracheal sacs, one on either side of the third abdominal segment. They are interconnected by means of a small branch which lies dorsal to the crop. In each of the following segments the lateral tracheal trunks are dilated into sacs which gradually decrease in size. From each of these, branches are given off to the spiracles, fat bodies and the organs lodged within the respective segments. It is remarkable that the trachae do not originate simultaneously from both the sides. In the third segment four trachea arise from the left sac dorsally to the ovarian filaments or testes which are kept in position by being encircled by one of the branches. A number of branches arising from various surfaces of the sacs also supply the ovarioles. Occasionally smaller sacs are given off from these dorsally or ventrally. In the fourth segment the sacs are slightly dilated and branches lead to the proventriculus, ventriculus and the genital organs. In the fifth segment branches go to malpighian tubules, gut and other organs. In the sixth segment the poison sac, the acid glands etc. are supplied and in the rest of the segments trachea go to the organs of copulation. The lateral tubes in the eighth segment end in minute branches after giving a stout branch to the eighth spiracle.

All the organs including muscles, nerves, heart brain and mouth parts are very richly supplied with these tracheal tubes which divide into very fine tracheoles so as to reach the furthest corner, (pl. fig. 5). Trachae run along the nerves into the substance of the salivary glands and muscle-bundles.

The two lateral tracheal trunks are dilated in each segment and constricted in the intersegmental area. They are interconneced by a number of transverse dorsal and ventral connectives, some of which form smaller sacs.

SUMMARY

The respiratory system of the wasp presents similar structure as found in other insects. Typically ten spiracles are present: of these two are thoracic, one is propodeal and the rest abdominal. There are usual branching tracheal tubes running to all parts and tissues of the body. Partly, respiration is also carried out through the thin and soft intersegmental membrane. In addition to this certain areas of flat cells in the proctodaeal region are suspected to be respiratory in nature.

ACKNOWLEDGEMENT

It is my pleasent duty to acknowledge my gratitude to Dr. L. P. Mathur, D. Sc., Registrar, Agra University, for his advice and assistance. I am also thankful to my colleagues whose cooperation gave me sufficient time to complete the work,

A NEW ECHINOSTOME CERCARIA FROM *Lymnaea luteola* WITH NOTES ON ITS LIFE HISTORY

By

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INTRODUCTION

On November 8, 1953, an undescribed species of echinostome cercaria was found in fifteen out of 90 adult *Lymnaea luteola* collected from a pond in Alfred Park, Allahabad. Its behavior and morphology were recorded and certain facts concerning the metacercaria were obtained. On November 10 of the following winter, more snails infected with this species were discovered. From experiments on the material thus obtained, metacercaria and adult stages were determined for a species which seems to be an undescribed form of *Echinoparyphium.* It was found that the same snails are second intermediate hosts and the adult matures in the intestine of domestic ducks (experimental). The name *Echinoparyphium bagulai* was proposed for the new species, which has been described and sent for publication in a separate paper.

The present form is described here under the name *Cercaria* (*Echinoparyphium*) *bagulai.*

THE CERCARIA (Fig. 1)

The cercariae always emerge from the body of the snail *Lymnaea luteola* in the mid of the day. They are very active swimmers and under average laboratory conditions they swim almost continuously for 8-9 hours or more. During this period there is no concentration of the cercariae but as they become weaker they become concentrated at the bottom. Swimming activities are similar to those of other echinostomes. The body may either precede or follow while swimming. Frequently an individual will settle down on a smooth surface and under go active creeping. During these creeping activities the body is constricted slightly just back of the acetabulum but not more so than in the case of any cercaria with a very protrusible acetabulum.

Description :—Body elongate with sides more or less parallel in posterior two thirds, slightly tapered anteriorly, widest portion just anterior to acetabulum. Collar spines 42 arranged in two rows. Oral sucker powerful, terminal and oval in outline. Acetabulum in mid of posterior half of body, very muscular, larger than oral sucker.

Cuticular spines very inconspicuous, most evident between two suckers. Prepharynx relatively long ; pharynx spindle shaped. Esophagus and ceca plain. Cystogenous glands composed of masses of fine rods mostly confined to lateral fields from level of pharynx to posterior end. Gland cells arranged in two groups situated lateral to oesophagus. Excretory bladder of two chambers, both contractile. Excretory canals arise antero-laterally from anterior chamber of bladder, enlarge immediately and extend forward, narrow abruptly at level of pharynx and reverse

their course and extend unbranched to extreme posterior end of body. Excretory granules evenly distributed in decending limbs. Flame cells 17 on each side. Tail powerful, plain, having no fins or folds and provided with both longitudinal and circular muscles to extreme tip. Caudal excretory tube bifurcates in first fourth of

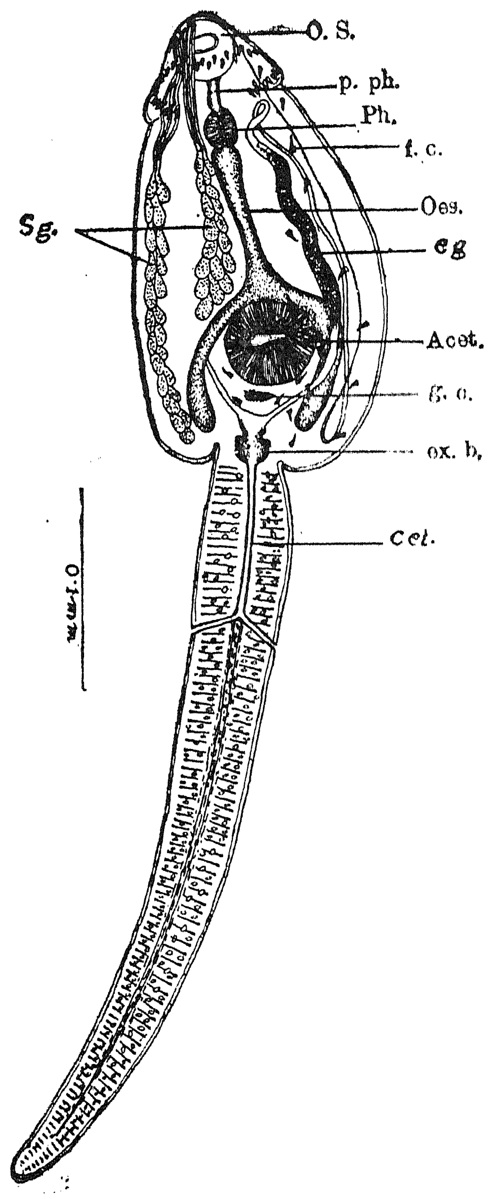

Fig. 1. Cercaria of *E. bagulai*, ventral view.
(Drawing made with the aid of a camera lucida)

Abbreviations used:—Acet, acetabulum; cet, caudal excretory canal; eg, excretory granule; ex. b, excretory bladder; f. c., flame cell; g. c., germ cells; Oes, oesophagus; O. S., oral sucker; Ph, pharynx; p. ph, pre-pharynx; Sg, salivary gland.

tail. Measurements on fixed material as in Fig. 1 body length 0·26 mm ; tail length 0·44 mm ; body width at acetabulum 0·12 mm ; oral sucker 0·033 mm; acetabulum 0·055 mm. by 0·042 mm.

THE METACERCARIA

Various species of fish, todpoles and snails were exposed to cercariae. All experiments with the first 2 were negative, but every attempt to infect snail of the species *Lymnea luteola* was succesful. Small snail (exprimental) and active cercariae were placed in shallow dish for several hours. Cercariae enter passively into the body of the snail and encyst in large number in the region of mantle and form a relatively strong primary cyst wall immediately. Cysts that are 20 hours old are fairly uniform in size and shape, 0·27 mm. by 0·18 mm. The cyst wall is less than 0·005 mm. thick.

The body of the metacercaria does not differ appreciably from that of the cercaria during the first few days after encystment. After 11 days the body is flexed ventrally, suckers become proportionately larger than in the cercaria and collar spines become clearly defined. The size and shape, number and distribution of excretory granules and spination of oral sucker remain unchanged after encystment.

THE ADULT

Metacercariae of various ages were fed to 2 white rats, 1 chicken, 1 pigeon and 1 domestic duck. All were negative when examined 5 and 7 days after feeding. Metacercariae under 3 weeks of age were again fed to domestic ducks, and 7 days later 6 immature worms were recovered from the intestine of the duck. Another duck was given over a period of 2 days, 2 snails, each of which carried 50 to 100 metacercariae. A severe diarrhea developed on the 13th day. On the 15th day, the duck died and 39 of the worms were found in the intestine.

Two important conclusions can be drawn from the above feeding experiments. The metacercariae are infective after 21 days of encystment. The domestic duck is a suitable laboratory host. The taxonomically important features of the experimental worms, such as vitellaria, ova and cirrus sac complex, were studied and have been described in a separate paper.

DISCUSSION

The echinostome cercaria of the new species *Echinoparayphium bagulai* exhibits only few specific characters by which it can be distinguished. It seems that cephalic spination is the only morophological feature which is most reliable and serviceable in the study of echinostome cercariae. The characters observed in the new form that the tail laking a fin fold; cystogenous cell abundant; main excretory canals extending to the pharynx and recuring, agree through out with the cercariae of *Echinoparyphium aconiatum* Dietz described by (Riech 1927) and Dubois (1928) ; *Echinoparyphium ellisi* Johnston and Angle (1949) ; *Echinoparyphium recurvatum* (Linstow, 1873) by Kuntz 1953 and *Echinoparyphium baculus* (Dies., 1850) by Ginetsinskaya (1949). The behaviour and general shape of the body, suckers and tail are identical. The new cercaria can be readily distinguished from other echinostome cercariae by the characters of 42 cephalic spines and absence of a tail fin membrane. It is quite true that the study of the cephalic spination is difficult in some forms and accuracy can not be easily attained. It than naturally follows that, too, much emphasis should not be placed on the similarity of the cephalic spination, but some attention may be given to other characters in distinguishing echinostome cercariae.

To be more convincing, life history must be carried on under well controlled conditions because echinostome cercariae definitly develop the same arrangement of spines in later stages.

As it is held by Cort, Faust and many others that the excretory system is also a important feature and provides a basis of classification. Sewell (1922) used the excretory system as one of the characters for separating the echinostome cercariae in four groups called, "*Echinatoides Coronata*, '*Echinata*' and '*Megalura*'. The last named was erected by Cort (1915). The present from resembles the '*Coronata*' group in having double rows of collar spines and tail lacking a fin fold.

Although the life cycle of *E. flexum* (Linton. 1892) is some what imperfectly known (Najarian, 1953), apparently it is the only species of the genus whose development, modes of transmission and hosts are known to closely resemble those of *E. bagulai* n. sp. The cercariae of both are minute and encyst in *Lymnaea luteola.* The metacercariae of *E. baculus*, (Ginetsinskaya, 1949) and *E. bioccalerouxi*, (Dollfus, 1953) also are found in molluscan hosts.

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BIBLIOGRAPHY

Dubois, G. (1928). Les cercaires de la Region de Neuchatel, *Bull. Soc. Sc. nat.* Neuchatel, **53**: 1-160.

Ginetzinskaya, T. A. (1949). New data on the life cycles of some Trematodes of birds. C. R. *Acad. Sci.*, Moscow N. S. 66,5, p. 1017-1020.

Johnston, T. H. & Angel, L. M. (1949). The life cycle of the trematode *Echinoparyphium ellisi*, from the black swan. *Rec. S. Aust. Mus*, Adelaide, 9,2, p. 247-254.

Kuntz, R. E. (1953). Development of the cercaria of *E. recurvatum* (Linst., 1873) Luhe, 1909 with emphasis on excretory system. G. S. Thaper Commemoration volume, Lucknow, 149-158.

Riech, F. (1927). Beitrage zur Kenntnis der Echinostomiden, Der Lebenszyklus von *E. aconiatum* Dtz. 11. *Cercaria laticaudata* n. sp., Central bl. f. Bakt., *Parasit.* Abt. I. Orig., **103**: 279-290.

Sewell, R. (1922). Cercariae Indicae. Indian *Journ. Med. Res.*, Suppl. **10**: 106-146.

THE INFLUENCE OF DIFFERENT SOURCES OF CARBON ON THE GROWTH AND SPORULATION OF *PESTALOTIOPSIS VERSICOLOR* (SPEG.) STEYAERT

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It has long been established that carbon as well as a number of other elements are indispensable for the growth of fungi. Carbon plays an important part because it forms about 50% of the total dry weight of a fungus. In nature carbon is mostly available in complex form, but generally fungi convert them into simpler water-soluble sugars of low molecular weight before utilization. Huge amount of literature has accumulated on the carbon requirements of fungi (Hawker, 1950; Lilly and Barnett, 1953; Wolf, 1953; Grewal, 1954 and Agarwal, 1958). The present paper reports the effect of different carbon compounds on the growth and sporulation of *Pestalotiopsis versicolor* (Speg.) Steyaert.

MATERIAL AND METHOD

Pestalotiopsis versicolor was isolated from spotted leaves of *Anogeissus latifolia* Wall (Agarwal and Ganguli, 1959).

Asthana Hawker's medium 'A' containing 5 gms glucose, 1·75 gms KH_2PO_4, 0·75 gm $MgSO_4 . 7H_2O$, 3·5 gms KNO_3 and one litre water was used as the basal medium. Glucose of the basal medium was singly substituted by different carbon compounds and their quantity was adjusted in such a way as to contain the amount of carbon as present in 5 gm of glucose per litre except for starch which was added in the same quantity as glucose. The following compounds were used :—

1. Carbohydrates
   - (*a*) Monosaccharides
     - Pentoses ($C_5H_{10}O_5$) - Rhamnose, xylose
     - Hexoses ($C_6H_{12}O_5$) - Glucose, galactose.
   - (*b*) Disaccharides ($C_{12}H_{22}O_{11}$) - Maltose, sucrose, lactose
   - (*c*) Polysaccharides $(C_6H_{10}O_5)_n$ - Starch
2. Alcohols - Mannitol ($C_6H_{14}O_6$), dulcitol, sorbitol
3. Organic acids - Oxalic acid $(COOH)_2$, tartaric acid $(COOH)_2$ $(CHOH)_2$

During the experiment only purest available chemicals, and Pyrex glass wares were used. Fifty ml of the culture media were taken in 150 ml Erlenmeyer flasks and sterilized at 15 lb pressure for 15 minutes. The pH of the different media before autoclaving was adjusted to 5 as this was determined to be the optimum pH for the organism. The flasks were incubated at room temperature for 15 days.

Table 1

Showing dry weight in mg. and sporulation of *Pestalotiopsis versicolor* on different carbon compounds.

Carbon compounds	Dry weight	Sporulation
Without any carbon	Nil	–
Rhamnose	209	poor
Xylose	200	nil
Glucose	252	good
Galactose	290	poor
Maltose	271	fair
Sucrose	255	good
Lactose	252	fair
Starch	186	poor
Mannitol	260	excellent
Sorbitol	248	fair
Dulcitol	195	good
Oxalic acid	nil	—
Tartaric acid	152	fair

The fungus did not grow in the absence of any carbon or on oxalic acid. The best dry weight was obtained on galactose and maltose. Next to them were mannitol, sucrose, glucose, lactose and sorbitol. They were followed by rhamnose, xylose, dulcitol, starch and tartaric acid. Sporulation differed in different compounds. Mannitol supported excellent sporulation and it was good on glucose, sucrose and dulcitol. Maltose, lactose, sorbitol and tartaric acid induced fair sporulation which was only poor on rhamnose, galactose and starch.

The assimilation of disaccharides by the microorganisms usually depends upon the production of the necessary hydrolytic enzymes. There are, however, records (Smith, 1949; Mandels, 1954), though few of direct utilization of disaccharides by some fungi. Tandon and Bilgrami (1957) observed that maltose and sucrose were utilized by some *Phyllosticta* species through a hydrolytic pathway and formed good carbon sources, whereas lactose was utilized directly and proved a poor carbon source. It may be that the disaccharides when utilized directly form comparatively poor carbon sources. The disaccharides support good growth of the organism, almost similar to that on glucose, and may thus be considered to be utilized through hydrolysis. Tandon and Bilgrami (1957) observed that there was no significant difference

in the dry weight of the *Phyllosticta* sp. on sucrose or on a mixture of its hydrolytic products. Hawker (1947), however, reported that the amount of mycelium produced by *Melanospora destruens* was different when this fungus was grown on sucrose or on a mixture of glucose and fructose. Her results indicated that it was not always essential that a complex carbohydrate (*e. g.* sucrose) or its hydrolytic products (*e.g.* mixture of glucose and fructose) should always be equally good sources.

Mannitol supported excellent sporulation as well as good growth. It was, therefore, attempted to find out the optimum concentration of mannitol for the vegetative growth and sporulation of the fungus. The organism was grown on 9 different concentrations of mannitol ranging from 0·05% to 8% as a sole source of carbon. The results are recorded in table II.

Table II

Showing dry weight in mg. and sporulation of *Pestalotiopsis versicolor* on different concentrations of mannitol.

Percentage of mannitol	Dry weight	Sporulation
0·05	87	good
0·1	146	good
0·2	208	excellent
0·5	256	excellent
1·0	310	good
2·0	482	good
4·0	600	fair
6·0	734	poor
8·0	701	very poor

The above table indicates that the fungus showed a marked increase in the vegetative growth with an increase in the amount of mannitol from 0·05% to 6% where it was maximum and beyond that there was a fall in the dry weight. The fungus grew even at the lowest concentration of mannitol *i. e.* 0·05% tried in the present experiment.

There was no correlation in the dry weight and sporulation. Sporulation was good from 0·05 to 2 per cent mannitol. At concentrations above 2%, there was a decrease in sporulation which was very poor at 8%. Considering the vegetative growth as well as sporulation 2% mannitol may be said to the optimum dose for the fungus.

SUMMARY

The influence of different sources of carbon on the growth and sporulation of *Pestalotiopsis versicolor* was studied. The best growth was obtained on galactose and maltose followed by mannitol, sucrose, glucose, lactose sorbitol, rhamnose, xylose, dulcitol, starch and tartaric acid. Oxalic acid could not be utilized. Mannitol supported excellent sporulation and it was good on glucose, sucrose, and dulcitol. Sporulation was poor on rhamnose, galactose and starch. The optimum concentration of mannitol for the vegetative growth and sporulation of the fungus was found to be 2%.

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REFERENCES

Agarwal, G. P. Nutritional studies on *Curvularia penniseti*. II. Carbon and nitrogen requirements. *Phyton*, **11**, 143-51, 1958.

Agarwal, G. P. and Ganguli, S. A leaf spot disease of *Anogeissus latifolia* Wall., due to *Pestalotiopsis versicolor* (Speg.) Steyaert. *Curr. Sci.*, **28**, 295-96. 1959.

Grewal, J. S. D. Phil. Thesis, Univ. Allahabad. 1954.

Hawker, L. E. Effect of temperature of storage on the rate of loss of fertility of stock cultures of *Melanospora destruens*, *Nature*, **159**, 136, 1947.

————. Physiology of fungi, Univ. of London Press, 1950.

Lilly, V. G. and Barnett, H. L. The utization of sugars by fungi., *West Virginia. agric. Expt. Stat. Bull.*, **262**, 38, 1953

Mandels, G. R. Metabolism of sucrose and related oligosaccharides by spores of fungus *Myrothecium verrucaria, Plant Physiol.*, **29**, 18-26, 1954.

Smith, V. M. On mechanism of action by *Marasmius chordalis. Arch. Biochem*, **23**, 446-72, 1949.

Tandon, R. N. and Bilgrami, K. S. Assimilation of disaccharides by some fungi causing leaf spot diseases., *Proc. Indian Acad. Sci.*, **46**, 274-84, 1957.

Wolf, F. T. The utilization of carbon and nitrogen compounds by *Ustilago zeae. Mycologia*, **45**, 516, 22, 1953.

FUNGI CAUSING PLANT DISEASES AT JABALPUR (MADHYA PRADESH)—IV

By

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Agarwal, Nema and Beliram (1959), Agarwal and Beliram (1960) and Agarwal (1960) have described in the first three series of the paper seventy six parasitic fungi occurring at Jabalpur. It is proposed to record some more fungi form Jabalpur in this fourth series.

The number of the species are the serial numbers of the fungus flora of Jabalpur.

PHYCOMYCETES

77. *Physoderma zeae-maydis* Shaw on leaves of *Zea mays* L., Adhartal, July, 1959, Leg. K. G. Nema.

78. *Choanephora cucurbitarum* (B. & Rav.) Taxt. on flowers of *Luffa acutangula*, Adhartal, August, 1958, Leg. Nema.

79. *Rhizophus nigricans* Ehrenberg. (Synonym *R. artocarpi* Raciborski) on fruits of *Artocarpus integrifolia* L., Richhai, February, 1959, Leg. Nema.

BASIDIOMYCETES

80. *Ustilago crameri* Koern on ears of *Setaria italica* Beauv., Adhartal, September, 1958, Leg. Nema.

81. *Ustilaginoides virens* (Cke) Tak. on panicles of *Oryza sativa* L., Adhartal, October, 1959, Leg. Nema.

82. *Uromyces fabae* (Pers) de Bary on leaves and stem of *Pisum sativum* L., and *Lens esculenta* Moench., Adhartal, January, 1959, Leg. Nema.

83. *U. appendiculatus* (Pers.) Lk. on leaves of *Phaseolus vulgaris* L., Adhartal, December, 1959, Leg. Nema.

84. *Puccinia helianthi* Schw. on leaves of *Helianthus annuus*, College area and Adhartal, Leg. Agarwal and Nema.

FUNGI IMPERFECTI

SPHAEROPSIDALES

85. *Diplodia natalensis* Evans. on leaves of *Mangifera indica* L., College Road, November, 1958, Leg. Agarwal.

86. *Phomopsis vexans* (Sacc. & Syd.) Harter on fruits of *Solanum melongena* L., North Miloniganj, January, 1959, Leg. Nema.

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87. *Septoria arcuata* Cke. on leaves of *Ficus bengalensis* L., Near College, October, 1959, Leg. Agarwal.

88. *S. lycopersici* Speg. on leaves of *Lycopersicum esculentum* Mill., Adhartal, December, 1959, Leg. M. D. Tewari.

It has also been reported from Madras State by Ramkrishnan and Sundaram (1954).

MILANCONIALES

89. *Colletorichum papayae* P. Henn. on leaves, petioles and fruits of *Carica papaya* L., Beoharbag, January, 1959, Leg. Agarwal.

90. *C. zingiberis* Sundaram on leaves of *Zingiber officinale* Rosc., Adhartal, September, 1959, Leg. Nema.

It has also been reported from Amalpur, Godavari (Butler and Bisby, 1931).

91. *Gloeosporium papayae* P. Henn. on leaves, petioles and fruits of *Carica papaya* L., Beoharbag, January, 1959, Leg. Agarwal.

92. *G. psidii* (G. Del.) Sacc. on fruits of *Psidium guajava* L., Adhartal, January, 1959, Leg. S. C. Dubey.

93. *Pestalotiopsis* sp. on leaves of *Artocarpus lacucha* Hort. Napier Town, January, 1958, Leg. R. C. Agnihotri.

47. *Pestalotiopsis versicolor* (Speg.) Steyaert on leaves of *Carissa carandas* L., Near Sahid Smarak, September, 1958, Leg. Miss Bhave.

This fungus has already been recorded on *Anogeissus latifolia* Wall. in series I of the paper and therefore the old serial number has been given to it.

MONILIALES

94. *Alternaria brassicae* (Berk) Sacc. on leaves of *Brassica oleracea* L., Adhartal, December, 1958, Leg. J. P. Bisen.

95. *Aspergillus niger* Van Tiegh. on bulbs of *Allium cepa*, Newarganj, January, 1960, Leg. Nema and Agarwal.

96. *Cephalosporium sacchari* Butler in culms of *Saccharum officinarum* L., Adhartal, December, 1959, Leg. Nema.

97. *Cercospora beticola* Sacc. on leaves of *Spinacia oleracea* L., Goshalpur, December, 1959, Leg. Nema.

98. *C. capsici* Heald & Wolf on leaves of *Capsicum annum* L., Adhartal, January, 1936, Leg. Nema.

Cercospora capsici has been reported on leaves of *Capsicum annum* also from Pusa and Kanpur (Butler and Bisby, 1931).

99. *C cucurbitae* Ell. & Ev. on leaves of *Cucurbits*, Adhartal, September, 1959, Leg. Nema.

100. *C. gossypina* Cke. on leaves of cotton, College area, November, 1958, Leg. Beliram.

It is the synonym of *Mycosphaerella gossypina* (Cke.) Atk. but only the conidial stages were seen. It is a common disease and found in many parts of India.

101. *Cladosporium fulvum* Cooke on leaves of *Lycopersicum esculentum* Mill., Adhartal, January, 1959, Leg. Nema & Agarwal.

69. *Curvularia lunata* (Wakker) Boed. on leaves of *Pancratium* sp., Beoharbag, September, 1959, Leg. Agarwal.

It has already been recorded on *Musa paradisiaca* and *Cymbopogon citratus* in series II of the paper and therefore the old serial number of the fungus has been retained here. *Pancratium* is a new host record for *Curvularia lunata* not so far described.

102. *Fusarium coeruleum* (Lib.) Sacc. on tubers of *Solanum tuberosum* L., Sunday Vegetable Market, December, 1959, Leg. Agarwal.

Fusarium coeruleum has been reported to be causing dry rot of potato and *Colocasia antiquorum* at Allahabad and the detailed pathological studies have been done by Tandon and Agarwal (1956).

103. *F. orthoceras* App. & Wr. on roots of *Cicer arietinum* L. and *Lens esculenta* Moench., Adhartal, January, 1959, Leg. Nema.

104. *F. oxysporum* Schlecht. on roots of *Pisum sativum* L., Adhartal, January, 1959, Leg. Nema.

105. *Oidium chrysanthemi* Rabh. on leaves of *Chrysanthemum* sp., Adhartal, November, 1959, Leg. Nema.

Oidium chrysanthemi has been reported on leaves of *Chrysanthemum* sp. also from Poona by Patel, Kamat and Bhide (1949).

MYCELIA STERILIA

106. *Rhizoctonia bataticola* (Taub.) Butl. on roots of *Cicer arietinum* L., and *Pisum sativum* L., Adhartal, January, 1960, Leg. Nema.

107. *Sclerotium oryzae* Catt. on stubbles of *Oryza sativa* L., Adhartal, December, 1958, Leg. Nema.

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REFERENCES

Agarwal, G. P. Nema, K. G. and Beliram, R., 1959, Fungi causing plant diseases at Jabalpur (Madhya Pradesh) I. *Proc. Nat. Acad. Sci., India*, 29-B : 310-315.

Agarwal, G. P. and Beliram, R., 1960, Fungi causing plant diseases at Jabalpur (Madhya Pradesh) II. *J. Indian Bot. Soc.* (in press).

Agarwal, G. P., 1960, Fungi causing plant diseases at Jabalpur (Madhya Pradesh) III. *J. Indian Bot. Soc.* (in press).

Butler, E. J. and Bisby, G. R., 1931, The fungi of India, Calcutta. *Sci. Monog. Coun. Agric. Res. India*, No. I.

Joshi, N. C., 1958, Fungi of Ajmer (Rajasthan) III, *Proc. Nat. Acad. Sci., India*, 28 B : 303-307.

Patel, M. K., Kamat, M. N. and Bhide, V. P., 1949, Fungi of Bombay. Suppl. I. *Indian Phytopathology*, 2 : 142-155.

Ramkrishnan, T. S. and Sundaram, N. V., 1954, Notes on some fungi from South India, IV. *Ibid.*, 7 : 140-151.

Tandon, R. N. and Agarwal, G. P., 1956, Dry rot of *Colocasia antiquorum* and potato caused by *Fusarium coeruleum* (Lib.) Sacc. *Univ. Allahabad Studies*, Bot. Sec.. 1-26.

Tandon, R. N. and Grewal, J. S., 1956, Effect of nitrogen nutrition on growth and sporulation of some pathogenic fungi. *Proc. Indian Acad. Sci.*, 44 B : 61-67.

A COMPARATIVE FUNCTIONAL STUDY OF THE URINO-GENITAL SYSTEM IN *UROMASTIX HARDWICKII* GRAY (SAND LIZARD) *PTYAS MUCOSUS* LINNE (RAT SNAKE) AND *ERYX CONICUS* BONLENGER (SAND BOA)

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I. INTRODUCTORY, MATERIAL & METHODS

In almost all the Universities in India, Pakistan, Burma and Ceylon the anatomy of a lizard and a snake is done by graduate and post-graduate students of Zoology, both in theory and practical classes. Yet no satisfactory account of their anatomy is available. Except for *Hemidactylus* (Mahendra 1935-1953), the rest of the reptilian investigations in India are scattered and sketchy. An excellent review of work abroad on reptilian urino-genital systems is given by Mahendra (1953), which is thus ommitted from the present paper. The urino-genital system, however, remains almost untouched in the reptiles of India, except for *Hemidactylus* (Mahendra, 1953) and a few short notes (McCann 1946, and Seshadri 1956,57) on reproductive organs of a few lizards and tortoises. The present contribution therefore lays down for the first time the outlines of Urino-genital anatomy in the important reptilian types mentioned above. The investigations were undertaken to find out the main differences in the urino-genital organs between Indian Lacertilian and Ophidian types, and also their functional anatomy.

The *Uromastix*, *Ptyas* and *Eryx* were all obtained in the living condition at Lucknow and dissected fresh after narcotisation by chloroform. The mesorchia, mesovaria and the broad ligaments were rendered opaque and easily visible in situ by the author's dilute corrosive without acetic technique. The numenclature abopted is after Beddard, Parker, Cope and Goodrich, with modifications.

II. THE URINARY SYSTEM

1. General

Although the urinary and genital systems are closely connected in Reptiles, and is jointly called the urino-genital system, the two systems develop independently and may be compared separately in the three reptiles dealt with in the paper. The urinary organs develop as 3 sets of segmental nephric tubules ; the pronephros, the mesonephros and metanephros, the functional kidney in the adult reptile being the metanephros. The mesonephros, present only in the embryo, atrophies in the adult ; but its duct functions as the epididymis and vas deferens in the male (Wölffian duct). The gonads, on the other hand, develop with no trace of metamerism from a pair of genital ridges which lie between the mesentary and the nephric fold. In the male they get connected with kidney tubules through vasa efferentia, but in the female no such connection is formed.

2. Uromastix hardwickii Gray

THE KIDNEYS AND URETERS

The *kidneys* in *Uromastix* are two depressed chocolate-coloured elongated pear-shaped structures which are free and broad in the anterior half of their length, but are fused along the rest two-thirds where they gradually taper up to the cloaca and form a V-shaped structure. Each kidney may therefore be said to consist of two lobes, as is found in *Hemidactylus* (Mahendra 1953), in which the free anterior part is the anterior lobe and the fused posterior part the posterior lobe, the tapering hind end of which extends somewhat beyond the transverse cloaca into the caudal region. The kidneys are located in the postero-dorsal part of the abdominal cavity, being closely applied to the dorsal wall, and are covered by peritoneum on their ventral surfaces only. The fused parts of the kidneys are not intimately united internally since each may be observed as a discrete structure in transverse sections, being separated from its fellow by the connective tissue matrix in which lie the caudal artery and caudal vein.

Arising from the anterior third of the ventro-lateral region of each kidney is a thin-walled short *ureter*, running imbedded in the central connective tissue inside the peritoneum. The openings of the 2 ureters into the cloaca lie in a special ventral pouch, the urodaeum, in its posterior half, and are separate and distinct from the openings of the vasa deferentia in the male and oviducts in the female (figs.) The ureter openings are situated on a slighty raised papilla. This is different from *Hemidactylus* (Mahendra, 1953) in which each ureter joins the vas deferens of its side posteriorly, and the two open together by one common aperture on a papilla in the urodaeal part of the cloaca. There are a pair of collapsed functionless ducts, the vestigeal Mullerian ducts which lie along-side the vasa deferentia in the male.

THE URINARY BLADDER AND URINE

The *bladder* is a whitish thin-walled elastic sac arising from the postero-ventral border of the urodaeum. The fundus is rounded but it narrows rapidly towords the urodaeum forming a well-marked pear-shaped sac. It contains a yellowish urine which is excreted from time to time into coprodaeum, a mechanism for conservation of water in these desert-living animals. The dried urine pellets when tested, shows about 80% uric acid, 6% allantoin and the rest calcium and salts. This is in contrast with *Hemidactylus* (Seshadri , 1956) which has 77% uric acid, 9% allantoin and the rest water and salts. The secretion of urine from the nephron capsules to the nephric tubules is not semisolid in any reptile, but some water is resorbed from the urine as it is passed through the distal convoluted tubules and finally poured into the coprodaeum for major resorption of water and solidification of urine.

3. Ptyas mucosus Linne

THE KIDNEYS AND URETERS

The *Kidneys* in *Ptyas* are not only asymmetrical in the same individual but their size and disposition are rather different in the male and the female snakes. The right kidney projects more than an inch in front of the left in a medium sized snake, in both the male and female. But in the male they reach the same level posteriorly and thus the right kidney is always longer than the left. In the

female snake the difference in length is not marked, the right stopping short before the left kidney posteriorly. Each kidney is an elongated, chocolate coloured, much-lobed depressed gland, the lobes appearing like so many segments arranged in tandem fashion. In the male the right kidney consists of about 20 segments, while the left one has only about 12 segments. In the female the right kidney contains about 12 segments and the left only about 9 segments. To compensate for length the kidneys in the female are not only broader but somewhat stouter than in the male (Figures). Each kidney tapers anteriorly as well as posteriorly.

The *ureters* arise from the anterior outer border of the kidneys, being joined by the segmental groups of urinary tubules as each ureter passes posteriorly. In the male each ureter crosses under the vas deferens of its side (figures) and opens by a separate opening in the urodaeum, posterior to the vas deferens openings. The two openings of the ureters are lodged in sacculated area of the urodaeum near a large raised papilla. In the female the lateral ureters make a wide loop under the enlarged part of the oviduct and open side by side posterior to the openings of the oviducts. In some other species of *Ptyas* examined (not *mucosus*) the ureter joins the enlarged part of the vas deferens (seminal sac) and both open by a common aperture at the urino-ganital papilla. The free posterior part of the ureters are much longer than in *Uromastix* and do not open so far back either, the free part being about one half the length of the kidney in the female and about one sixth its length in the male.

THE URINE

Snakes have no urinary bladder and this structure is also absent in *Ptyas*. The urine in *Ptyas* is solid and whitish, a dirty-coloured thick liquid being stored in the special chamber (coprodaeum) and dehydrated before being voluntarily excreted. The dried urine contains about 78% uric acid, 1·5% urea, and the rest ammonia, aminoacids, creatinine etc., showing that it is less deserticolous than *Uromastix*. The urea, absent in *Uromastix*, is present here, while the allantoin present in *Uromastix* is absent in *Ptyas*.

4. **Eryx conicus** Boulenger

THE KIDNEYS AND URETERS

The *Kidneys* in *Eryx* are not only situated farther up from the cloaca than in *Ptyas* but they show a much greater lobulation or segmentation than in *Ptyas*. The right kidney is far ahead of the left being about 4/5ths of kidney length anterior to the right one in the male and 3/4ths in the female. Each kidney consists of five (and only five) segments in a row, being separated by whitish transverse partitions of connective tissue. Each is depressed, chocolate coloured and spindle-shaped in outline, being pointed both anteriorly and posteriorly. The anteriormost or first lobe in each kidney is conical, the apex of the cone being directly forward; while the posterior or fifth lobe is about the same size and shape as the first, the apex of the cone however being directed posteriorly. The rest 3 lobes or segments are broader than long, the middle one being the broadest and the other two somewhat narrower and shorter.

The *Ureters* in *Eryx* arise neither from the anterior end nor are they mesial or lateral in position. They originate from under the first lobe of the kidney lying ventrol to it and run along the entire length of each kidney on its ventral median line, dividing the kidney into almost equal right and left halves. This a very

peculiar arrangement not reported in any other reptile so far. On reaching the posterior border of the kidney each ureter thickens and runs posteriorly as the free ureter for a length about three times the kidney length on the right and twice the kidney length on the left side. The free ureters in the female are somewhat longer than in the male. Each ureter opens separately, opposite its fellow, into the hind part of the urodaeum, the gential openings (one pair) being situated in its front part. The ureters do not cross the vasa deferentia as in *Ptyas*, and the oviducal apertures also do not lie anterior to the ureter openings.

THE URINE

There is no urinary bladder and whitish solid urine is stored in a special compartment of the coprodaeum before being voluntarily excreted. Thus although the ureters and vasa deferentia both open into the urodaeum, the urinary chamber is separate from the genital one. I have recovered almost solid balls of uric acid from the cloacal chamber of some specimens of *Eryx*. The percentage composition of dried urine has 88% uric acid, 1·5% amino-acids, 2% purines, and the rest salts and creatinine. In this respect (the hard solid urine and the 88% uric acid), the urine of *Eryx* is similar to that of the horned toad *Phrynosoma* (a desert lizard) and is thus much more deserticolous than *Ptyas*. *Eryx* has neither urea or allantoin.

III. THE REPRODUCTIVE SYSTEM

1. General

In the reptiles the mesonephros and its ducts have been taken over entirely into the service of the testis. The mesonephros has lost its kidney structure and become incorporated into the testis as a portion of the epididymis. The mosonephric duct (pronephric primitive longitudinal duct) forms the rest of the epididymis and vas deferens (Wölffian duct) in the male. In the female the mesonephros and its ducts atrophy and may be present as a vestige known as the Rosenmuller's organ or canal of Gartner. The Müllerian duct persists as the oviduct in the female and as a vestigeal strand in males. The eggs are fertilised in the oviduct and receive a coating of albumen and then a membranous or calcareous shell in their passage down the oviduct. Male snakes and lizards always possess paired (double) organs of copulation, which consist of protrusible hollow pockets of the cloaca and are called the hemipenes. When protruded the surface of each hemipenes is traversed by a groove (the sulcus) which conveys the spermatic fluid from the genital openings in the cloaca of the make into the cloaca of the female.

2. Uromastix

The *testes* in the male are two whitish void bodies placed asymmetrically much anterior to the kidneys. The right testis is situated only a little ahead of the left one and may even lie at the same level or in reversed situations in many individuals. Each testis is attached to the bodywall by a fold of peritoneum called mesorchium which is broader than that found in *Lacerta* or *Hemidactylus* and is separate from another fold, the "broad ligament", supporting the epididymis and extending anterior to the mesorchium. In the male the Müllerian vestige lies as a pair of peritoneal thickened strands antero-median to the testes and parallel to vas deferens posteriorly, the Wöffian vestige lying obliquely at posterior margin of each testis. In the female the Wölffian vestige (Rosen muller's organ) is situated antero-laterally to the ovaries.

The *epididymis* is a well-developed part of the Wölffian duct which is the thickened, convoluted part of the vas deferens and begins at the postero-lateral margin of each testes (not from the inner side of each testis as in *Lacerta*), being continued backwards as a thick cord to about half the distance between the testes and kidneys. Each epididymis passes behind into a narrower less convoluted tubule the *vas deferens*, which runs ventrally along the middle of the kidney of its side and approaches its fellow posteriorly to open separately but side by side in the anterior part of the urodaeum. The vasa deferentia do not join the ureters.

The structure of the *copulatory organs* of the male, viz., the hemipenes, have been described for many reptiles (McCann 1946). In *Uromastix* they consist of a pair of hollow eversible copulatory sacs opening into the posteriormost part of the cloaca and attached by retractor muscles passing from the hinder end to a number of caudal vertebrae. The shape and size of each hemipenis is dependent upon the degree of eversion (as in *Hemidactylus*) ; but it has a distinct hardened pedicil, a soft anterior glans, and a sulcus along outer wall.

The *ovaries* in the female are a pair of oval bodies with irregular outline, the right ovary being usually a little anterior to the left one, although the situations may be level or even the reverse in some individuals. The ovaries are situated nearer the kidneys than the testes. The mesovarium is a thin narrow sheet attaching each ovary with the dorsal abdominal wall, and the "broad ligament" supporting the oviducal funnel and anterior part of the oviduct. Each ovary contains ova in various stages of development, the larger ones lying on its anterior border.

Each *oviduct* originates by a wide-mouthed thin-walled funnel, opening into the anterior abdominal cavity, the openings of the funnels facing outwards and not inwards as in *Hemidactylus*. The oviducts run posteriorly lying outer to the ovaries without any convolutions ; but each presents a striated appearance throughout due to special elastic fibre-bands (figures). The posterior part of each oviduct is enlarged into a shell gland or *ovisac* which not only lodges the mature fertilised egg but secretes part of the egg-shell. The last part of the eviducts form the socalled "vaginae" of the lizard, where the sperms of the male are discharged after copulation, and which open into the anterior part of the urodaeum by a pair of large openings.

3. Ptyas

In the male *Ptyas*, the *testes* are not only placed far away from the cloaca and anterior to the kidneys but they are acutely asymmetrical and placed almost in a line, tandem fashion, one in front of the other. The right testis lies two lengths ahead of the left testis, and the left testis is nearer the left kidney than the right testis is to the right kidney. Each testis is an elongated cylindrical yellowish structure, almost five times as long as broad, and is attached by a long narrow mesorchium to the dorsal body wall. Each testis consists of 5 to 6 thickened lobes or segments arranged in a linear fashion and therefore look like a kidney except for its yellowish colour. The "broad ligaments" are smaller and narrower than in *Uromastix*.

The *epididymis* is an elongated convoluted strip lying along the outer border of each testis upto its posterior end, and does not extend beyond as in *Uromastix*. Each vas deferens is a very long thin duct running from the epididymis along the outer side of the ureters and, crossing over the ureter, opens in the proximal part

of the urodaeum in a groove (near the urinary papilla) which leads in an arc down into the basal groove (basal sulcus) of the hemipenis of its side. Each hemipenis is about half as long as the right kidney and bears a groove (sulcus spermaticus) along which sperms pass to the tip of the glans.

The *ovaries* in the female *Ptyas* are much longer and broader and cylindrical than the testis, although situated at almost the same level tandem fashion as the testes in the male. The right ovary is much larger than the left and is situated about two lengths ahead of the left ovary very near the median line. Each ovary consists of only one lamella containing a single row of eggs, and not the double lamellae characteristic of most snakes. The 2 ovarian funnels lie opposite and outer to the ovaries, with the oviducal aperture directed inwards. The female has a long yellow *peritoneal organ* attached to the inner margin of each ovary and running almost four-fifths of its length from the posterior margin. This structure has been homologised with the adrenal of higher vertebrates. The mesovarium is narrow and only as long as the ovary; while the "broad ligment" is only a thin strip on its antero-lateral margin.

The *oviducts* are somewhat wavy in their course from the abdominal funnels, the right oviduct being about 1 2/3 the length of the left one. Each oviduct, on reaching behind the kidneys, becomes enlarged to form a thickwalled *ovisac* which also serves for storage of sperms after copulation for fertilisation of descending ova and for secretion of certain parts of the egg which is stored here until it is laid. The two ovisacs open through a pair of female genital apertures lying in the proximal part of the urodaeum.

4. Eryx

The *testes* are a pair of compact whitish bean-shaped or kidney-shaped organs in the male *Eryx*, which are placed asymmetrically far anterior almost about a kidney-length to the kidneys. The right testis is situated about one testis-length ahead of the left, but not in a tandem line as found in *Ptyas*. The mesorchia are weak but the "broad ligament" is quite well-marked. Each testis is stout and presents a smooth appearance without being lobed as in *Ptyas* or other snakes. In this feature *Eryx* resembles the Lacertilia rather than ophidia.

The *epididymis* is narrow and short beginning from the inner middle region of each testis, and is continued posteriorly into the vas deferens which follows a wavy sinuous course. Each *vas deferens* is whitish, thin walled, and passes on the outer sides of the kidney to open separately, the two openings lying side by side in a pouch on the roof of the proctodaeum. The vasa deferentia do not cross the ureters as in *Ptyas* and each opens into the cloaca near a groove which becomes functionally continuous with the base of the sulcus. Each *hemipenis* in situ is shorter and stouter than in *Ptyas* and a little more in length than its short compact kidney.

The *ovaries* are a pair of very long translucent tubular bodies, situated far apart on the dorsolateral sides of the abdomen a little ahead of the kidneys. The right ovary is longer than the left and not only begins nears the kidney of its side but extends further forwards than the left one by about half a kidney-length. Each ovary consists of the double lamella with an intervening sinus, the larger eggs always lying in the anterior part of the ovary which thus tapers posteriorly. The peritoneal organ is small, the mesovarium narrow, and the "broad ligament" is very narrow and elongated.

The *oviducts* run an almost straight course backwards from the narrow oviducal funnels lying much ahead of the ovaries. Although each oviduct becomes stouter as it runs posteriorly on the outer side of the kidney, there is no distinct ovisac as in *Ptyas*. The two female genital apertures lie side by side in a special chamber in the urodaeum. The oviducts do not cross the ureters in *Eryx*.

IV. THE CLOACAL DIVISIONS

1. General

The primary divisions of the cloacal chamber in reptiles into a *corprodacum*, an *urodacum* and a *protodacum*, is now universally accepted. The *coprodacum* is really the last part of the rectum which is separated proximally as well as distally by well-marked sphincter muscles. Usually it is constricted into a number of small chambers, the last chamber opening into the urodaeum through a strong sphincter. The *uradacum* receives : (1) the urinary secretion through the ureters, and (2) the sperms through the vasa-deferentia in the male or the ova through the oviducts in the female. The urodacum is often further subdivided into a ventral urinary and a dorsal genital chamber, so that the two products may remain separate. The *proctodacum* is the shallow last portion of the cloacal chamber, which can be functionally juxtaposed to either the coprodaeum or the urodaeum, and opens externally by a large transverse cloacal aperture to allow for the eversion of the hemi-penes.

2. Uromastix

The *coprodaeum* is larger than the urodaeum and opens by a narrow sphinctered passage into the latter distally ; while proximally it is demarcated from the rectum by a mild sphinctered transverse fold. The wall of the coprodaeum shows internal folds which disappear on stretching, unlike *Hemidactylus* (Seshadri, 1956) where strangely enough the right half is shown to have folds, and the left none. There are no villi such as are found in the intestinal wall. The lining of the sphincter separarating the coprodaeum and the urodaeum has high ridges and deep grooves set longitudinally, some of which coalesce and pass insensibly into the neck of the urinary bladder. The urinary bladder stores the urine passed antero-ventrally from the urodaeum and passes it again from time to time into the coprodaeum which absorbs the water. The wide folded sphincter region keeps the urine from passing into proctodaeum and its folds also absorb the water.

The *urodaeum* can be shut off from the coprodaeum by a strong sphincter, and receives in the male the ureters and vasa deferentia in separate areas, of which the former may be functionally isolated and juxtaposed with the proctodacum separately. The urodaeum may thus be separated into a dorsal genital and a ventral urinary half. In the female the oviducal apertures lie on the dorsolateral sides of the ureter openings and can be separately juxtaposed with the proctodaeum. Each vas deferens falls into an urodeal diverticulum which forms a pair of functional seminal vesicles to store sperms which are shed only at copulation. The urodeal lining is slightly folded and has no villi either.

The *proctodaeum* or the third chamber of the cloaca is the widest, and communicates through the thick-lipped transverse cloacal aperture to the outside. The coprodaeum, urodaeum, and proctodaeum are never in a straight line of sequence as shown in the figures of Seshadri (1957). It is rather an S-shaped affair, the bends lying in a dorso-ventral axis. The lining of the protodaeum is the smoothest

except for the lateral openings of the hemipenis in the male *Uromastix*. The large transverse cloacal aperture allows for extrusion of the copulatory organs in the male, the organs themselves lying outside the cloaca.

3. Ptyas

The three chambers are never at level or in a line in *Ptyas*, but in three tiers. The *coprodaeum* is at a lower level than the urodaeum, while the proctodaeum lies still ventral to the urodaeum. The coprodeal chamber is the largest of the three chambers and is lined by a folded and ridged epithelial layer, which is made smooth by stretching. Its opening into proctodaeum is guarded by a thick valvular partitions, the urodaeum lying out of the path on the dorsal side.

The *urodaeum* is triangular in shape and again separable functionally into an urinary and a genital part, the openings of vasa deferentia in male lying antero-dorsal to the ureter openings, the flow of urine being automatically directed into the lower coprodaeum without the intervention of a bladder. This is helped by the uro-proctodeal passage being functionally blocked by the raised posterior margin of the urodaeum (see figure), and by the ureters opening behind this urinary ridge (papilla). In the female the oviducts open antero-dorsally to the ureters.

The *proctodaeum* is the widest of the three chambers and is much more differentiated than in lizards. There are three *proctodeal ridges* : a thick median dorsal ridge and two broad lateral ones, between which lie two well-marked dorso-lateral *proctodeal grooves*. These two deep shaped grooves connect directly the genital chamber of the urodaeum to the margins of the two hemipenes sheath openings, the mechanism of working of which will be discussed later. On the sides of the transverse cloaca lie the two hemipenes sheath openings and still outer to these is the small opening of the post-anal gland on each side.

4. Eryx

The coprodaeum, urodaeum and proctodaeum are situated on the same plan as in *Ptyas*, but the unrodaeum is the largest of the three chambers, and the walls of the cloaca as well as the partitions are more well-developed and compact.

The *coprodaeum* is deep and very extensible with a large number of villi-like folds. This is a definite advance over *Uromastix, Hemidactylus* and *Ptyas*, since it is here that the urine is dehydrated or rendered solid. There is no urinary bladder.

The *urodaeum* is placed high (dorsal) above the proctodaeum, and the uro-proctodeal junction is guarded by a conical ridge pointing backwards. This cone is the urinary papilla on which both ureters open on its anterior face.

The *proctodaeum* is broad, shallow and has proctodeal dorso-lateral grooves, as in *Ptyas*. But unlike *Ptyas* the ridges as well as grooves are very shallow. The hemipenis sheath openings are thick-lipped and large, while the postanal glands are vestigeal and have very small openings (see figure).

V. THE HEMIPENES, POST-ANAL GLANDS AND PREANOFEMORAL PORES

1. General

The male copulatory organs in reptiles are generally stowed away beneath the skin in recesses of the postero-lateral corners of the shallow cloacal vestibule. In general each organ is attenuated at the free end and furnished with "horny" processes, and is called a *hemipenis* (or half penis). Each is a tubular structure, to the free end of which is attached a long retractor muscle which arises from the ventro-lateral surface of the caudal vertebrae and extends a considerable distance back. It has been observed that only one hemipenis is inserted into the cloaca of the female at one time.

The earliest appearance of copulatory organs is seen in the lizards (*Uromastix*) where there is actually no copulation (as understood in higher vertebrates) but the penis is a means to secure juxtaposition of the sexual apertures rather than an organ of intromission of spermatic fluid. The *hemipenes then are actually organs of prehension* which can take a firm hold on the cloaca of the female.

The *postanal sacs* or glands are specialised glandular structures which play an important part in sexual congress by emitting the characteristic odour of the sex and species. The *pre-ano-femoral pores* are the openings of certain pre-anal and femoral glands in Geckonidae, Lacertidae, Varanidae and Dibaenidae. They are not found in all genera and may be restricted to males only in some (Gockonidae) or present in both males and females (Lacertidae).

2. Uromastix :

There are 9-18 *preanofemoral pores* arranged in a single row along under surface of thigh and par-anal region on each side in *Uromastix* ; some of the pores lie in the scales but others are actually surrounded by them. The pre-anal pore-line form an angle of about 120⁰ with the femoral pore-line. Preanofemoral pores are absent in all oriental Agamidae except *Uromastix, Physignathus* and *Leiolapis*. Each pore leads into a tubular invagination of the epithelium which is only a simple tubular gland. On examination the secretion of the glands appear to consist of epidermal horny or scaly matter without odour. The secretion may increase and become deep yellowish in the breeding season. The actual function of the secretion of these glands appears uncertain but they have been suggested as aids to mating in *Uromastix* and other lizards where they are present.

The two *hemipenes* lie in two sacs or sheaths under the skin ventrally at root of tail and open into cloaca one on each side in the proctodaeum. Each hemipenis on eversion is seen as an oblong club-shaped organ with corrugations on its surface, a few scattered spines ore hooklets on its surface. There is a stalk or pedicel at base of hemipenis and the club or body is flounced to form calyces with spinous interruptions. Each hemipenis is eversible, when erected, like the finger of a glove and there is a ventral grove in each for transmission of sperms.

The *anal glands* (cloacal glands) lie on either side of base of tail and open on the sides of the penial openings immediately behind the vent. They are rudimentary and about the same size in both males and females, and are small and void in shape. The viscous secretion is yellowish and with a definite odour, the secretion increasing during the breeding period.

3. Ptyas

Each *hemibenis* extends upto 10th or 12th caudal plate, and at rest the two halves are retracted outside-in into the base of tail. The organ is much elongated and scarcely differentiated from the long retractor muscle which runs almost up to end of tail. Each hemipenis is an unforked cylinder somewhat enlarged at the penultimate distal end. Five zones may be discerned in a fully erected hemipenis : (1) a narrow smooth basal zone without spines, (2) a wide fleshy spinous zone reaching to about half the length of the hemipenis with 8-10 rows of spines, (3) a third zone having widely separated transverse grooves and ridges forming flounced folds, (4) a finely ridges zone (the thickest part of the penis) with very narrow transverse grooves and ridges, and (5) a terminal narrowed region without any ridges or spines. Besides these there are a pair of very large fleshy spines at the base of each hemipenis which locks the organ in situ after insertion into the female. There are no flounced calyces as metioned by Malcolm Smith (1943) nor is there any division into two by a sulcus as maintained by McCann (1949). The *sulcus spermaticus* or sperm groove is narrow and passes along the outer wall of the hemipenis upto the tip. The smooth fleshy lip of the penis resembles the *glans* of many higher vertebrates.

The *postanal glands* (sacs) are in the form of two hard chitinous pads situated internally to the retracted hemipenis and are sufficiently large to be mistaken for the hemipenes in *Ptyas mucosus*. Their two openings lie just outer to the penial openings and are small. The viscous secretion of these glands has a strong "snake o lour", characteristic of the species. There are no preanofemoral pores or glands in snakes.

4. Eryx

The two *hemipenes* are shorter than those of *Ptyas* and there are well-marked rows of chitinous spines which, however, are only 5-6 in number. The spines are harder than in *Ptyas* and are no doubt more efficient in grasping or prechension. The sperm groove bifurcates near the tip of the organ, although the hemipenis is not forked. The ridged middle region to characterised by oblique folds (not transverse as in *Ptyas*). The flounces join distally to form cup-shaped depressions.

The *post-anal sacs* (glands) are small and reduced to two wedges on the inner sides of the hemipenes, being hardly discernible as separate glands. They may possibly become larger in the breeding season, when they are functional. The preanofemoral pores or glands are absent.

VI. DISCUSSION AND FUNCTION

1. Excretion

A study of the functional anatomy of the urinary organs of *Uromastix*, *Ptyas* and *Eryx* reveals, that the atrophied Müllerian duct is present in the lizard *Uromastix*, and is absent or lost in the snakes, *Ptyas* and *Eryx*. An atrophied Wölffian may also be seen in *Uromastix*, but not in the snakes examined. The act of urination (excretion of fluid urine) appears to be a continuous process. But this urine never comes out of the body even in snakes, although there is no urinary bladder in snakes. In *Uromastix*, the urine is passed ventro-anteriorly along the longitudinal grooves at the copro-urodeal junction and some of it thus reaches the coprodaeum straightaway. But the ridges described as leading into the bladder guide the rest of the urine laterally into the bladder where the urine is stored. Thus in snakes (which have no urinary bladder) the flow of urine must be very slow to be retained in the comprodaeum directly.

The extraction of water takes place in the coprodaeum in all the above-mentioned reptiles, as observed also for *Hemidactylus* (Seshadri 1956). The solid urine is retained in the coprodacum until the act of defaecation when some faecal matter pushes out the urine and becomes attached to it posteriorly. Urine is thus excreted outside the body as a solid. *Uromastix* has allantoin but no *urea*, *Ptyas* has urea but no allantoin, while *Eryx* has neither allantion nor urea. From this analysis it is apparent that *Ptyas* is fond of water or is least deserticolous ; *Uromastix* is fond of a drier habitat, and *Eryx* is almost as deserticolous as the horned toad *Phrynosoma.*

2. Reproductive Organs

The *testes* appear slightly asymmetrical in most reptiles as it is in *Uromastix*, but it reaches the acme of asymmetry in snakes. In *Eryx* the right testis lies on the right, but one testis-length ahead of the left one ; while in *Ptyas* the testes lie tandem fashion one in front of the other the right one lying two testis-lengths ahead of the left one. The testes are ovoid in *Uromastix*, bean-shaped in *Eryx* and become very much elongated in *Ptyas*, being about five times as long as broad.

The *epididymis* (the only functional part of the Wölffian duct) forms the long comvoluted part of the vas deferens, extending far posterior to testis in *Uromastix* ; it is broad and short in *Ptyas*, not extending beyond testis ; while in *Eryx* it is narrow and shortest.

The *ovaries* are also placed asymmetrically. They are only slighty so in *Uromastix* ; the right extends half a kidney length ahead than the left one in *Eryx* ; while in *Ptyas* not only is the right ovary much longer than the left one but it lies about two and a half lengths ahead of the left one in the median line in tandem fashion.

The *oviducts* are also asymmetrical and each is enlarged posteriorly to form a thick-walled ovisac in both *Uromastix* and *Ptyas*. But the ovisac is absent in *Eryx*, since this viviparous snake does not have to store eggs or secrete a shell for the egg.

3. The Hemipenes, copulation and oviposition

The copulation, insemenation and oviposition of reptiles is so widely different that there may appear no underlying plan in these processes. However, closer study reveals one pattern which is typically lacertilian, and in the case of snakes another typically ophidian. The *lacertilian copulation* and insemenation, as exemplified by *Uromastix*, consists of the male and the female lying side by side, the lateral turning over of the tail away from each other, and the juxtaposition of the male and female cloaca. This is usually after some minutes of sex-play in which the male is far more active than the female.

Immediately after opposition of the cloaca, the erected hemipenis of the male, on the side nearest to the female, is everted like the finger of a glove by fluid pressure, there being no extensor muscle for the extension of the organ. The hemipenis is inserted into the proctodaeum of the female from where the distal end makes its way into the genital chamber of the *Urodaeum*. This is closed off from the urinary chamber ann the conical 'glans' of the hemipenis may pass directly into the oviducal aperture. The spermatic fluid is discharged and passed finally into the ovisacs by contractions of the urodaeum, the fluid passing through the sperm groove (*sulcus*) on the outer surface of the hemipenis.

Fertilization is effected high up in the oviduct and the fertilised ova are lodged in the ovisac after receiving coats of yolk, albumen, shell membrane and finally the shell. Oviposition takes place only when several ova are mature, fertilised and shelled, usually in the burrow in which *Uromastix* lives.

In the ***ophidian type*** the hemipenes are not only much larger but, since snakes have no limbs for prehension of the female by the male, they usually undertake sexual congress by entwining around each other (and even erecting the anterior half of the body, above the ground in a pre-copulatory dance) and adhering at the cloacal region by the insertion of the two long hooked or spiny hemipenes. Snakes do not lie side by side in sexual congress but are always applied ventrally, at least in the cloacal third of the body.

The male snake may be easily recognised by distinct thick-enings on either side of base of tail caused by the retracted hemipenes. The external openings of the hemipenes may be seen by lifting the anal shield in a snake, one on each side of the transverse cloacal aperture which allows its exersion. The hemipenis of *Ptyas*, with its five regions, may be said to typify the organ in snakes, although even *Eryx* has a greatly different hemipenis.

Functionally, the anatomy of the cloaca and structure of hemipenes justify the sexual congress in snakes to be called a true *copulation*. The male cloaca is so constructed that the urodaeum is raised high above the proctodaeum which has not only a median interlocking ridge but two lateral proctodeal grooves which are converted into sperm canals at coitus. The two elongated erected hemipenes in *Ptyas* are inserted simultaneously into the cloaca of the female, where two similar lateral grooves in the proctodaeum lead the 'glans' end of each organ straight into the oviducal aperture of its side. More than half of each organ inserts right inside the distal part of oviduct (the ovisacs) where the spermatic fluid is deposited.

Copulating snakes may be lifted right out of the ground or water but their copulatory "hold" is not easily released. This is due to the double action of : (1) the swelled enlarged penultimate part of the hemipenis lying inside the shinctered oviducal aperture and (2) the base of the organ being firmly held in the female cloaca by the rows of erected flashy spines and the two enlarged basal spines in *Ptyas*. This strangle-hold on the male copulatory organ is comparable with the similar phenomenon in copulation of the mammal *Canis familiaris*. The spermatic fluid is passed along the longitudinal groove or spermatic sulcus of each hemipenis into the respective oviducts. In *Eryx*, as there is no ovisac, the copulatory organs are inserted high up in the oviducts and the sperms discharged there.

Snakes may remain ***in copulo*** from fifteen minutes to as long as two hours or so, the copulatory organs not necessarily remaining inserted all that time. I have observed *Ptyas* in sexual congress for over an hour and a half, although the cobra may remain coupled for five hours or so (Wall 1920). This coitus may be repeated in snakes for three or four days.

Copulation takes place only when the ova are mature and breaking away from the ovaries to enter the oviducal funnels or ostium abdominale. The fertilised ova move down the thickwalled lower oviducts where secretion of yolk and albumen takes place around the egg. Finally, the shell is secreted around the egg by the shell glan ds of the ovisac or terminal part of the oviduct (*Ptyas*). The eggs are laid deep inside loose earth or humus, the base of a heap of putrifying dead fallen leaves being a favourite place for the oviposition. The female snake does not guard or hatch the eggs which are left to hatch in the heat of decomposition and insolation,

The egg of *Ptyas* when laid is about the size of a pigeon egg, but more soft and cylindrical than the bird's egg.

VII. SUMMARY

The present paper gives a detailed account of the functional anatomy of the urinogenital system, copulation and oviposition in *Uromastix* (a typical lizard) and two snakes : (1) Oviparus *Ptyas* and (2) Viviparous *Eryx.*

The functional morphology of the excretory organs of the snakes *Ptyas* and *Eryx* is given here for the first time.

The ovaries and testes both show tandem arrangement in *Ptyas*, both being extremely elongated and displaced. *Eryx* is more akin to the lacertilian pattern, although it is more descerticolous than either *Ptyas* or *Uromastix.*

The urine of *Uromastix* has allantoin but no urea ; *Ptyas* has urea but no allantoin ; while *Eryx* has neither allantoin nor urea.

The male copulatory organs are hemipenes (the two halves of a single penis) which show the following features : (1) both hemipenes are everted together ; (2) the erected organ has a dilated head or glans when everted ; (3) the organs establish a firm hold within the female and this compensates for the absence of any external hold during copulation in snakes ; (4) the spermatic fluid passes into a functionally produced canal or tube at copulation, which leads the fluid into the spermatic sulcus of the hemipenis ; and (5) fertilization is internal in the upper reaches of the oviduct in all the three reptiles studied.

VIII. REFERENCES

Beddard, F. E. (1904 *a, b, c*), Contributions to the anatomy of the Lacertilia ; (1, 2 & 3) : On some points in the vascular system of lizards, Chameleon and other lizards, *Proc. Zool. Sc. London*, 6-22 ; 436-450 ; 465-470.

————(1904 *d*), Notes upon the anatomy of certain snakes of the family Boidae. *Proc. Zool. Soc. Lond.*, **2**, 108-121.

————(1905), Some additions to the knowledge of the anatomy principally of the vascular system of *Hatteria, Crocodilus*, and *Lacertilia. Proc. Zool. Soc. London*, 461-489.

————(1906*a*) Contributions to the anatomy of the Ophidia. *Proc, Zool. Soc. London.*, **1**, 12-44.

————(1906*b*), On the vascular system of *Heloderma* with notes on that of monitors and Crocodiles, *Proc. Zool. Soc. London*, 601-625.

Bhatia, M. L. (1929), On the venous system of *Uromasttx hardwickil, Zool. Anz.*, **85** (1-2), 15-27.

Bhatia M. L. and J. Dayal, (1933), On the arterial system of the lizard *Hemidactylus flaviviridis* Ruppel. *Anat. Anv.* **76**, 417-337.

Boulenger, G. A. (1890), Reptilia and Batrachia. *Fauna Brit. India, London*,

Braun, M. (1878*a*), The primitive kidney and sexual organs in *Anguis fragilis*. *Arb. Inst. Würzb*, **4**, 138-145.

————(1878*b*), The primitive kidney and sexual organs of *Lacerta agilis*. *Arb. Ins. Würzb*, **4**, 132-137.

Brooks, P, (1906), The anatomy of the virinogunital organs of certain North American lizards, *Trans. Texas. Acad. Sci.*, **8**, 23-38.

Buxton, P. A. (1955), "Animal life in deserts". London (Edward Arnold).

Cope, E. D. (1894), On a collection of Batrachia, and Reptilia from the Island of Hinan, *Proc. Acad. Philadel*, **1**, 423-428.

————(1896) On the hemipenis of the Sauria. *Ibid*, Philadelphia, 232-238.

D'Abrean, E. A. (1915), *Eryx conicus* breeding in captivity. *J. Bom. Nat. Hist. Soc.*, **24**, 193-194.

Das, G. M., & B. K. Das (1932), Observations on the *ductus caroticus* and *ductus Botalli* of *Gecko verticillatus*, *Anat. Anz.*, **73**, 289-320.

DeSilva, P. H. D. H. (1956), The heart and aortic arches in *Calotes versicolor* (Daulin) with notes upon the heart and aortic arches in *Calotes calotes* (Linne.) and *C. nigrilabris* Peters. *Spol Zeylan*, **28** (1), 55-82.

————(1956), The arterial system of *Calotes versicolor* (Daudian) with notes upon the arterial system of *Calotes calotes* (Linne.) and *C. nigrilabris* Poters. *Spol. Zeylan*, **28** (1), 68-102.

Forbes, T. R. (1941), Observations on the urinogenital anatomy of the adult male lizard *Sceloporus*, *J. Morph Philadelpaia*, **68**, 31-61.

Gadow, Hans (1898), Remarks on the cloaca and copulatory organs of the amniota. *Phil. Trans. Roy. Soc. London*, **178B**, 5-37.

Hank. B. P., Osler, B. L. & Summerson, W. H. (1954), Practical physiological Chemistry. (London, Churchill Ltd.).

Hoffman, C. K. (1889), Zur entwickelungegeschichte der urinogenital organe bei des Reptilien. *Z. Wiss Zool.* **48**, 266-300.

Kaushiva, B. S. (1940), The arterial system of the pond turtle, *Lissemys punctata* (Bounaterre), *Proc. Ind. Acad. Sci. Sec.* B, **12**, 84-96.

Khalil, F. (1947), Excretion in Reptiles : I. Non-protein Nitrogen constituents of the urine of the sea-turtle *Chelonl mydas* L. *J. Biol. Chem.*, **171** (2), 611-616.

————(1948*a*), Excretion in Reptiles : II. Nitrogen constituents of the urinary concretions of the viviparous snake *Eryx thebaicus Reuss*. *J. Biol. Chem.*, **172**, 105-106.

————(1948*b*), Excretion in Reptiles. III. Nitrogen constituents of the urinary concretions of the oviparous snake, *Zamenis diadenk*, *J. Biol. Chem.*, **172**, 107-114.

Khalil, F. (1951), Excretion in Reptiles. IV. Nitrogenous constituents of the excreta of lizards, *J. Biol. Chem.*, **175**, 214-236.

Mahendra, B. C. (1942), Contributions to the bionomics, anatomy, reproduction and development of the Indian House Gecko, *Hemidactylus flaviviridis* Ruppell ; Pt. III ; The Heart and the venous system, *Proc. Ind. Acad. Sci.*, **15** (5), 231-252.

McCann, C. (1937), Notes on the breeding of the rat-snake or Dhaman (*Zamenis mucosus*), *J. Bom. Nat. Hist. Soc*, **39**, 423-424.

————(1946), The Hemipenis in Reptiles. *J. Bombay Nat. Hist. Soc.*, **46** (2), 348-373.

Moyle, Vivien (1949), Nitrogenous excretion in Chelonian reptiles. *Biom. J.*, **44**, 581-584.

Murthy, V. V. (1951), A special feature of the excretion of the house-lizards, *J. Sci. Ind. Res.*, 8.

Noller, G. K. and Bradley, H. T. (1933), The mating behaviour of lizards and its bearing on the theory of sexual selection Ann., *New York Acad. Sci.*, **35**, 25-100.

O'Donoghue, C. H. (1912), Circulatory system of the grass snake, *Tropitodonotus natrix*, *Proc. Zool. Soc. London*, 1912, 612.

O'Donoghue, C. H. (1916), A note on the *ductus caroticus* and *ductus arteriosus* (d. Botalli), and their distribution in the Reptilia, *J. Anat. & Physiol., London*, **2**, 137-149.

————(1920), The Blood Vascular system of the Tuatera, *Sphenodon punctatus*, *Phil. Trans. Roy. Soc., London*, **210** (B), 175-282.

Prossor, C. L. (1951), Comparative animal physiology, W. B. Saunders Co. Ltd. Philadelphia and London, 888 pp.

Roy, H. C. (1934), On the arterial system of the common Indian snake, *Ptyas mucosus* Linne. *J. Morph.* **56**, 533-575.

————(1936), On the venous system of the common Indian Rat-snake *Ptyas mucosus* L. *J. Morph.*, **59**, 517-544.

Schoff, F. (1888), Beitrage zur Keuntniss des urinogenital systeme der Saurrier, *Arch. f. Nat. Liv.*, 62-80.

Seshadri, (1956*a*), Urinary excretion in the house lizard, *Hemidactylus flaviviridis* (Ruppel) *J. Zool Soc. India*, **8**, 63-68.

————(1956*b*), Urinogenital organs and urinaty excretion in the pond turtle, *Lissemys punctata punctata* (Bonn.) *J. Zool. Soc. India*, **8**, 99-112.

————(1957), Water conservation in *Uromastix hardwickil* (Gray), with a note on the presence of Müllerian ducts in the male, *J. Zool. Soc. India*, **9**, 103-113.

Sharma, S. (1954), The venons system of *Varanus monitor* (Linn.), *Proc Zool. Soc. Bengal,* **7** (2), 69-89.

Smith, M. (1934), The Fauna of British India, Ceylon, and Burma. Reptilia and Amphibia Vol. II, *Sauria.*

———(1943), The Fauna of British India, Ceplon and Burma. *Reptilia and Amphibia (Revised),* Vol. III, *Serpentes.*

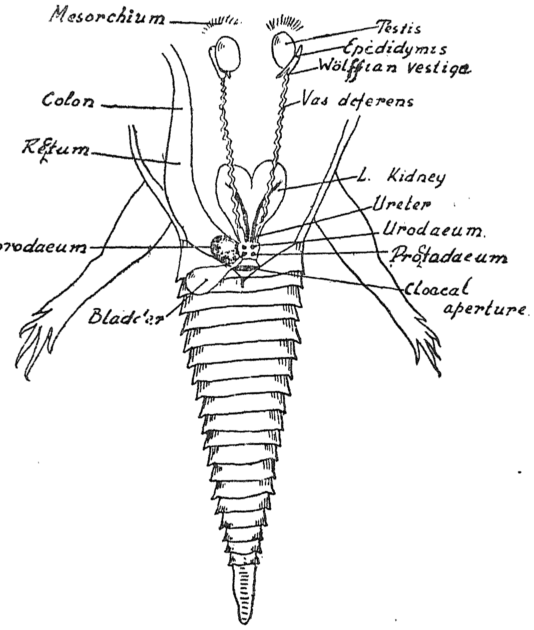
Thapar, G. S. (1923), On the arterial system of the lizard *Varanus bengalensis* (Daud.), with notes on *Uromastix* and *Hemidaetylus,* J. *Asiatic Soc. Beng., Calcutta,* **19** (1).

Thomson, J. C. (1913), Contribution to the anatomy of Ophidia, *Proc. Zool. Soc. London,* 1413-1416.

———(1914), Further contributions to the anatomy of Ophidia, *Proc. Zool. Soc. London,* 379.

Wopke, K. (1931), Die Kloake and die Begattungsorgane der mannlichen Zanneidechse (*Lacerta agilis L.*) *Z. Naturwiss, Jenar,* **65** (2), 273-316.

Plate I



Uromastix hardwickii—male

Plate II

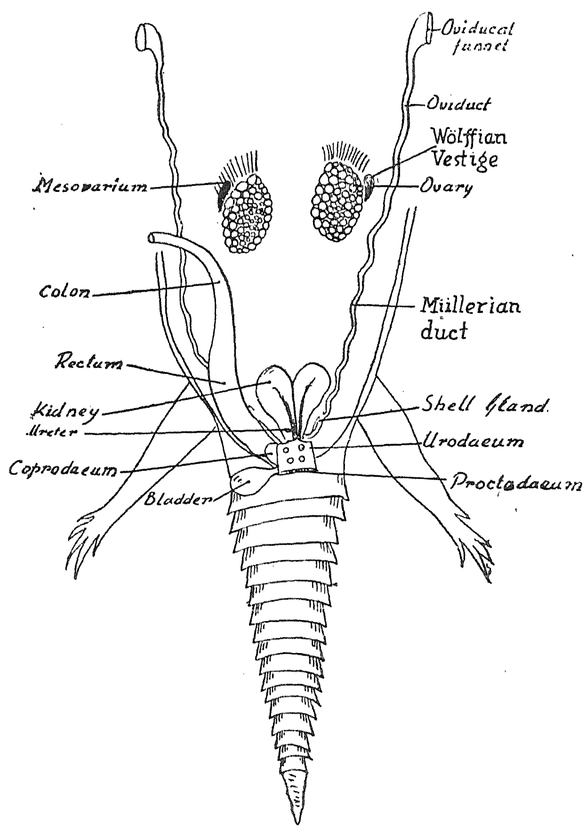
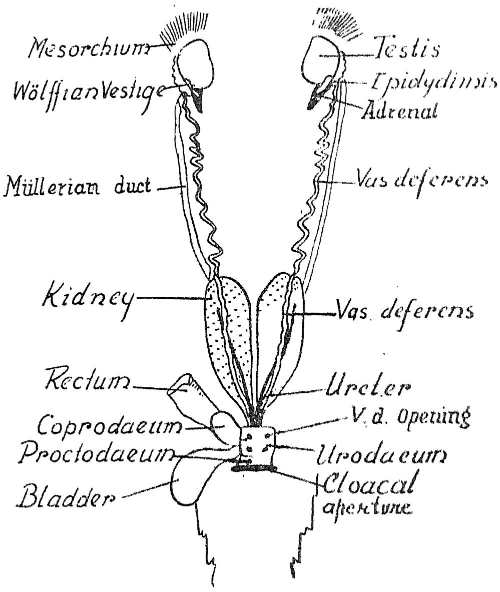
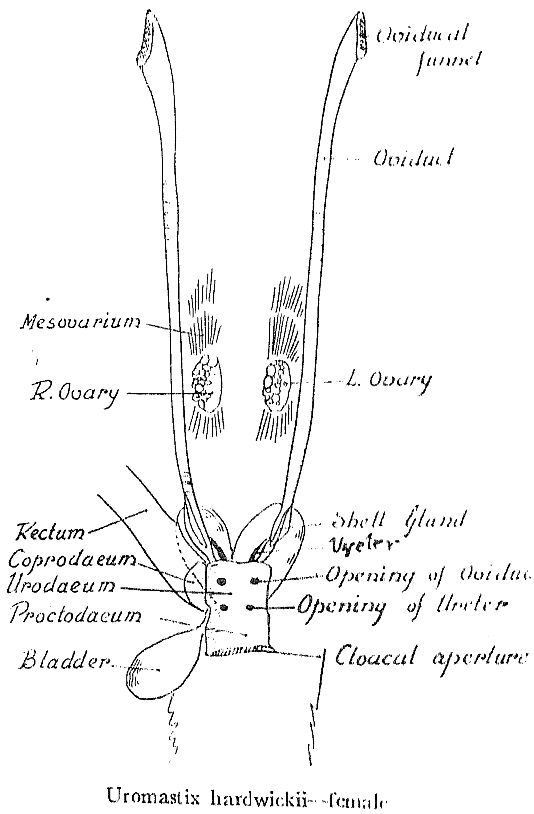


Plate III



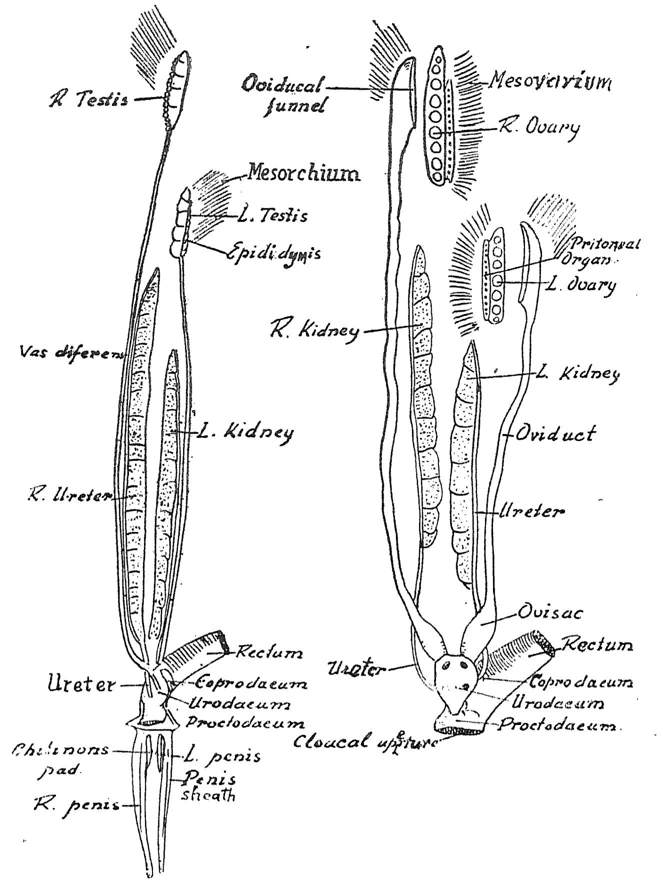
Uromastix hardwickii—male

PLATE IV



Uromastix hardwickii—female

PLATE V



Ptyas Mucosus—male and female

Plate VI

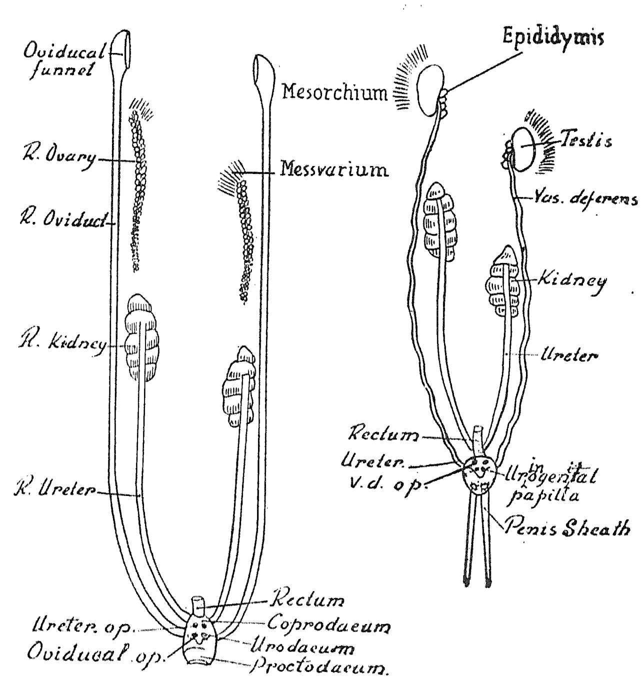
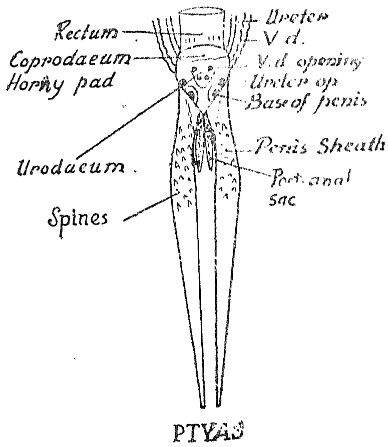
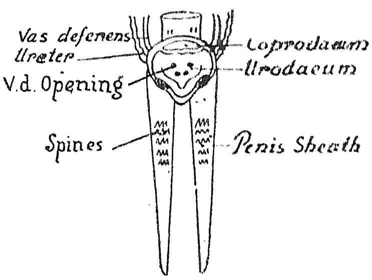


PLATE VII



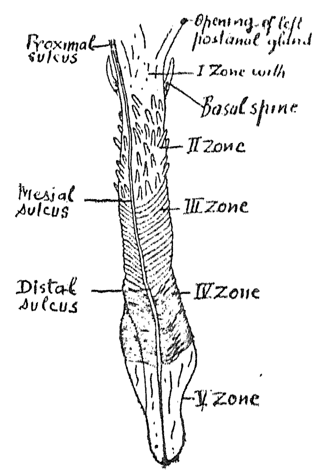
PTYAS



ERYX

Hemipenis of *Ptyas* and *Eryx*

PLATE VIII



Ptyas mucosus—Hemipenis

A NOTE ON THE ANTERIOR VEINS OF THE INDIAN SAND LIZARD UROMASTIX HARDWICKII GRAY

By

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The venous system of many reptiles has been worked out in detail e. g. *Sphenodon, Crocodilus, Lacertilia* (Beddard 1905) ; *Tropidonotus, Sphenodon* (O'Donoghue 1912, 1920) ; *Ptyas* (Roy 1936) ; *Varanus* (Thapar 1922, Sharma 1954) ; etc. But the paper on venous system of *Uromastix* (Bhatia 1929) omits, strangely enough, the entire anterior veins of the animal. *Uromastix* is used as a reptilian type in almost all Indian Universities for the graduate and post-graduate classes. The present note attempts to remove this gap in our knowledge by which students as well as teachers are severely handicapped specially because the anterior veins of *Lacerta*, sketched in most text-books of Zoology, are quite dissimilar to those in *Uromastix* (fig. 1).

THE PRECAVALS

The lacertilian pattern of a right and a left *precaval* carrying blood from the anterior extremities and the head to the *sinus venosus* is maintained in *Uromastix*, each precaval receiving four veins before it falls into the sinus venosus : (1) *Laryngo-tracheal* (2) *Intercostal*, (3) *Subclavian* and (4) *Jugular sinus*. But the left external jugular vein is not absent as in *Lacerta*. On each side the *cerebral* vein from the brain and *orbital* from the orbital region of the head join to form the *internal jugular* vein ; while the *maxillary* from the upper jaw and face and the *mandibular* vein from the lower jaw, join to form the *external jugular* vien. These two veins, the internal and the external jugulars, join each other on reaching the level of the tympanum (ear), lying far internal to it, and form the common jugular vein.

The stout *common jugular* vein runs down posteriorly from the level of the ear into the neck region, where it receives a long vein on its outer side, the *temporal* (often mistaken for the external jugular), bringing blood from the temporal and auditory regions of the head. In the neck region each common jugular expands into a venous sinus called the *jugular sinus*.

At the junction of the jugular sinus with the posterior vena cava falls a large *subclavian* vein. Each subclavian is formed by the union of three veins : (1) the *scapular*, bringing venous blood from the shoulder region ; (2) the *brachial* collecting blood from the forelimb ; and (3) the axillary vein from the inner basal region of the forelimb and the thorax (fig. 1).

Before entering the pericardium, each pre-caval receives a third vein, the *intercostal*, which is directed posteriorly along the inner wall of the thorax and collects blood from that region. Both pre-cavals enter the pericardium at the same level and, passing through its antero-lateral walls, fall into the large sinus venousus. Just before it falls into the sinus venosus each precaval receives a fourth vein, the *Laryngo-tracheal*.

THE TRACHEAL LOOPS (ANASTAMOSES)

The *laryngo-tracheals* (thyro-tracheal of some) are two symmetrical long vein each originating in the mental region by junction of a *laryngo-mental* and a *lingual* vein from the Larynx and the tongue respectively. The Laryngo-tracheals, run backwards, one on each side of the trachea, almost throughout its length. They are nearer each other at the anterior end and diverge posteriorly to join the pre-caval, close to their opening into the sinsus venosus.

The two Laryngo-tracheals are joined by transverse half loops which are usually three to four in number and have been named here *tracheal loops* (anastamoses). They are a constant and very characteristic feature of *Uromastix*. The first tracheal loop is the shortest and lies just behind the junction of laryngo-mental and lingual veins. The second and third loops lie close together in the anterior region of the neck, level with the junction of the temporal vein with jugular sinsus. The fourth tracheal loop lies posteriormost, at level with the jugular sinus and thyroid gland, and is the longest of the four observed in *Uromastix hardwickii*. Very rarely a fifth loop may be present, lying in between the first and the second tracheal loops.

The Laryngo-tracheals receive along their course small veins from the larynx, trachea, oesophagus and thyroid gland.

DISCUSSION

The symmetrical arrangement of the anterior veins, in contrast with that of *Lacerta*, shows that *Uromastix* is a more primative lizard, with the additional primitive arrangement of four large veins going into the formation of the anterior vena cava. The anterior vena cava is formed in lizards generally, as in *Hemidactylus* (Mahendra, 1942), by the union of three veins : (1) a tracheal, (2) a common jugular, and (3) a subclavian. In a few, as in *Varanus*, there is union of *only two* : (1) the common jugular, and (2) the subclavian. The union of *four veins* : (1) the common jugular, (2) the subclavian, (3) the intercostal and (4) the laryngo-tracheal, found in *Uromastix* anterior vena cava, is certainly more primitive than the two of *Varanus* and the three of *Hemidactylus*. The differences from *Varanus* (Sharma, 1954) are also well-marked in the anterior veins, since the four "plexuses" (Thapar, 1922) join the external jugulars while they are short in *Uromastix*.

The branches of the subclavian show chelonian features, there being only three branches : (1) the axillary, (2) the brachial and (3) the scapular. In *Varanus* (Sharma, 1954) it is formed by the brachial, v. anastomica longa, and a v. cutanea magna.

The most serious drawback to my mind in all the descriptions of anterior veins in lizards is the terminology. While Thapar (1922) says there are two external jugulars in *Varanus* showing anastamoses (his "plexuses"), Sharma (1954) denies the very existence of the external jugular vein in *Varanus*. Then again the *Vena mandibularis* is planted on the internal jugular by Sharma, whereas it really belongs to the external jugular in vertebrates. I also find no reason for continuing the practice of calling the common jugular vein as *Vena jugularis communis* and the paired intercostals (azygos of Sharma) as *Vena azygos dextra* (right) and *Vena azygos sinistra* (left) etc. etc. as has been done for the veins by Sharma (1954).

In plain language, the external jugular is not absent in Uromastix (or for that matter in Varanus). What happens is hat a split junction or displacement

of some of the elements of the external jugular in these lizards takes place, if we keep in mind the same embryological elements as mentioned by Luschka, Grosser and Brezina. Not only have the lingual and mandibular parted company in *Uromastix*, but the maxillary and the mandibular veins join to form a distinct vein which must be considered as an external jugular. Moreover the temporal (with auricular) should also be considered as a separated element of the external jugular.

The three or four tracheal loops (anastamoses) should also be considered as a primitive feature in lizards as exemplified by both *Uromastix* (Das) and *Varanus* (Sharma).

REFERENCES

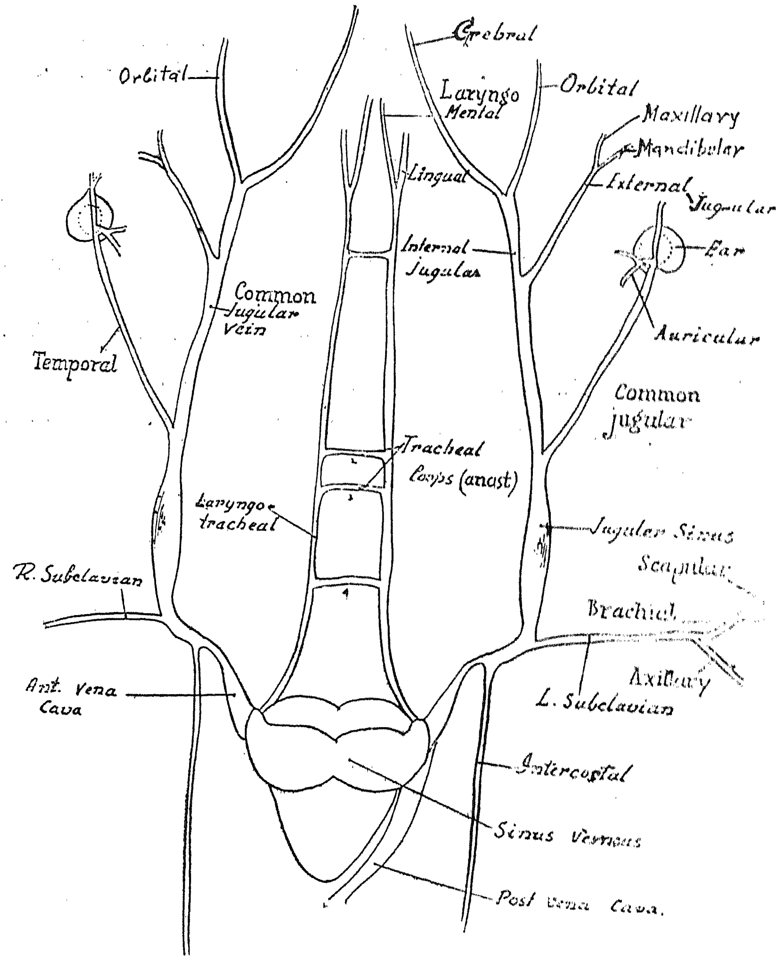
See list of references in previous paper on *Uromastix hardwickii* Gray, *Ptyas mucosus* Linne, and *Eryx conicus* Boulenger.

Grosser, O. (1907), Die Elemente des Kopf venens system der trirbeltiere, *Anat. Anz.*, **30**, 179-192.

Grosser, O. & Brezina E. (1895), Uber die Entwickelung der Venen des Kopfes und Halses bei Reptilien. *Morph. Jahrb.* **23**,|289-325.

Luschka, H. (1862), Die Venen des menschlichen Halses, *Densckr. Acad. Wiss. Wien.*, **20**, 119-225.

Plate IX



Anterior veins of Uromastix hardwickii

STUDIES ON A NEW SPECIES OF THE GENUS *ORIENTOCREADIUM* (TREMATODA: ALLOCREADIIDAE) FROM THE INTESTINE OF *CLARIAS MAGUR*

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INTRODUCTION

The genus *Orientocreadium* was created by Tubangui, in 1931 to include *O. batrachoides* Tubangui, 1931. Pande (1934) and Yamaguti (1934) added two more species Viz., *O. indicum* Pande, 1934, and *O. pseudobagri* Yamaguti, 1934, to this genus. Yamaguti (1953) considered the genera *Neoganada* Dayal, 1938, *Ganada* Chatterji, 1933, and *Nizamia* Dayal, 1938, synonymous to the genus *Orientocreadium.* Saksena (1958) supported the above synonymity and pointed out the similarity of the genus *Ganadotrema* Dayal, 1949, with the genus *Orientocreadium* and included all the species of the genera *Ganada, Neoganada, Nizamia* and *Ganadotrema* in the genus *Orientocreadium.* Simultaneously Yamaguti (1958) had shown the genera *Ganadotrema* Dayal, 1949, and *Paratormopsolus* Dubinina et Bychovsky, 1954, alongwith the genera *Ganada, Neoganada* and *Nizamia,* synonymous to the genus *Orientocreadium.* Yamaguti (1958) propose *O. dayali* for *Ganadotrema indica* Dayal, 1949, which becomes *O. indicum,* which in turn becomes a homonym of *O. indicum* Pande, 1934. As *O. dayali* is preoccupied the author suggests *O. bharati* for Dayal's species.

Tubangui (1933) placed *Orientocreadium* in the subfamily Allocreadinae Looss, 1902. Pande (1934) showed the similarity of the *Orientocreadium* with the genus *Plesiocreadium* Winfield, 1929, and placed the genus *Orientocreadium* in the subfamily Plesiocreadiinae Winfield, 1929. Yamaguti (1958) created a new subfamily Orientocreadiinae to include the two genera—*Orientocreadium* Tubangui, 1931, and *Macrotrema* Gupta, 1951.

In this communication one more species of the genus Orientocreadium viz., *O. umadasi* n. sp. has been described. The parasites were obtained from the intestine of fresh water fish *Clariasmagur* during the months of May and June 1959 at Raipur.

ORIENTOCREADIUM UMADASI n. sp.

(Text Fig. 1)

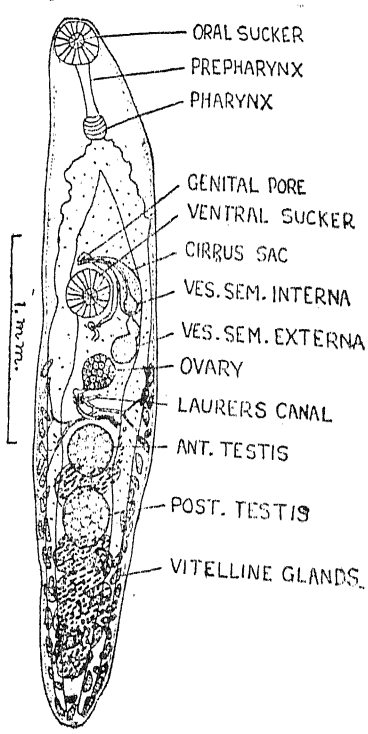
It is a spindle shaped trematode, measuring 4·12 – 2·69 mm. in length and 0·59 mm. in breadth at the level of the anterior testis. The cuticle is thin and is covered with minute backwardly directed spines.

The Oral sucker is subterminal in position and measures 0·22 – 0·21 mm. in diameter. It lies at the distance of 1·16 – 0·91 mm. from the anterior end. Prepharynx is comparatively long measuring 0·21 – 0·18 mm. in length and 0·09 – 0·06

mm. in breadth. The pharynx measures 0·14 – 0·11 × 0·14 – 0·11 mm. in size. The oesophagus is very small. The intestinal caeca extend upto posterior end of the body and have crenated outer margins at the commencement.

The excretory pore lies at the posterior end of the body and leads into a tubular bladder which extends upto the posterior testis. The gentital pore is located above the acetabulum slightly to the left of the median line.

There are two oval testes which lie one behind the other in the posterior half of the body. The anterior testis is situated at a distance of 1·88 – 1·58 mm. from the anterior end, and measures 0·25 – 0·22 × 0·22 – 0·18 mm. The posterior testis is 0·28 – 0·25 × 0·24 – 0·18 mm. in size. The distance between the two testes is 0·028 mm. The posterior testis is slightly larger than the anterior testis.



Text Fig. 1. *Orientocreadium umadasi* n. sp. Dorsal View

The cirrus sac is a well developed curved organ, embracing the acetabulum on the right side upto its posterior margin. It is 0·42 – 0·36 mm. in length and 0·11 – 0·08 mm. in breath at the basal region. It contains oval vesicula seminalis interna, 0·098 – 0·09 × 0·06 – 0·05 mm. in size, tubular pars prostatica surrounded by prostate gland cells and the spiny cirrus. The vesicula seminalis externa is a bilobed structure, extending from the basal level of the cirrus sac to the anterior surface of the ovary. The proximal lobe of the vesicula seminalis externa measures 0·08 – 0·07 × 0·05 mm. and its distal lobe measures 0·14 – 0·01 × 0·11 – 0·05 mm.

The ovary is pretesticular, oval in shape, and lies in the median line at a distance of 1·55 – 1·27 mm. from the anterior end. It measures 0·17 – 0·1 × 0·17 mm,

in size. The oviduct arises from the posterior margin of the ovary and opens at the ootype which lies between the ovary and anterior testis. The receptaculum seminis is absent. Laurers canal is present.

The vitelline glands are lateral in position. They extend from the anterior level of the ovary to the posterior end of the body where they meet with each other. The transverse vitelline ducts lie above the anterior testis. They meet to form a common vitelline duct which opens at the ootype.

The uterus consists of transversely coiled limbs which cover the area from the level of the anterior testis upto the posterior end of the body. The ascending limb extends anteriorly on the right side of the acetabulum and forms a well developed metraterm which opens at the genital pore. The eggs are oval in shape measuring $0.03 \times 0{\cdot}015 - 0{\cdot}012$ mm. in size.

DISCUSSION

Orientocreadium umadasi n. sp. differs from all the known species of the genus Orientocreadium except *O. hyderabadi* (Dayal 1938) Yamaguti 1953 in possession of bilobed vesicula seminalis externa. It differs from *O. hyderabadi* in shape of the testes and ovary, prepharynx comperatively long, the suckers being approximately equal, and the size of the body. This new species is named after Professor Umadas Mukerji, the founder Principal of the College of Science, Raipur, where parasites were collected.

ACKNOWLEDGEMENTS

The author is grateful to Dr. S. S. Saxena, Professor of Zoology and the Principal, M. L. B. College, Gwalior, and Dr. Shamacharan Srivastava, Professor of Zoology, for providing the research facilities in the department. Thanks are also due to Dr. R. N. Singh, Head of the Zoology Department, Science College, Raipur, for taking keen interest in this work and for his valuable suggestions.

REFERENCES

Chatterji, R. C. 1933. Parasites of a Rangoon siluroid, fish *clarias batrachus*. *Bull. Acad. Sci. U. P.*, **3**, 33-40.

Dawes, Ben, 1946. "The Tremetoda" Camb. Univ. Press.

Dayal, J. 1938. Studies on the trematode parasites of fishes. A new trematode *Neoganada barabankiae*. Nov. Gen. Nov. sp. from *clarias batrachus* *Proc. Ind. Acad. Sci. B.* **7**, 132-137.

Dayal, J. 1938. Studies on the trematode parasities of fishes. A new trematode, *Nizamia hyderabadi* N. Gen. Nov. sp. from the intestine of a fresh water fish *Ophiocephalus punctatus*. *Proc. Nat. Acad. Sci. Ind.* **8 (2)**, 53-58.

Dayal, J. 1949. Trematode parasites of India, fishes, part II. *Ind. Jour. Helminth*, I (2), 109-120.

Gupta, S. P. 1951. Trematode parasites of Indian fishes. Three new trematodes of the sub-family Leptophallinae Dayal, 1938 from the fresh water fishes of U. P. *Ind. Jour. Helminth.* III (1), 29-40.

Gupta, S. P. 1951. Studies on the trematode parasites of food fishes of U.P. *Ind. Jour. Helminth,* III (2), 101-108.

Pande, B. P. 1934. On a new trematode from the Indian fresh water fish. *Proc. Nat. Acad. Sci.* 4(1), 107-112.

Saksena, J. N. 1958. Studies on two new species of the genus *Orientocreadium* (Trematoda, Allocreadiidae) from the intestine of *Clarias magur, Proc. Nat. Acad. Sci. India.*, Vol. XXVIII, Sec. B, Part I, 58-64.

Tubangui, M. A. 1931. Trematode parasites of Philippine Vertebrates III. Flukes from fish and reptiles. *Philipp. J. Sci.*, **44** (**4**), 417-423.

Tubangui, M. A. 1933. Trematode parasites of Phillippine Vertebrates VI. Description of new species and classification. *Philipp. J. Sci.* **52(2)**, 167-197.

Winfield, G. F. 1929. *Plesiocreadium typicum* a new trematode from *Amia calva. Journ. of Parasit.*, Vol. 16, 81-87.

Yamaguti, S. 1934. Studies on the helminth fauna of Japan. Part 2. Trematodes of fishes, I. *Jap. J. Zool.* **5**(3), 249-541.

Yamaguti, S. 1953. "Systema Helminthum", Part I. Digenetic trematodes of fishes. Published by the Author, Tokyo, Japan.

Yamaguti, S. 1958. Systema Helminthum, Vol. I. The digenetic trematodes of vertebrates Part I & II. Interscience Publisher . New York.

THE ANATOMY AND HISTOLOGY OF THE DIGESTIVE ORGANS AND MALPIGHIAN TUBES OF OXYRHACHIS TARANDUS FABR.
(Membracidae)

By

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I. INTRODUCTION

There hardly exists any adequate account of the digestive organs of the Membracidae (Homoptera). The only record beiog that of Kershaw (1913) who has given a brief account of the alimentary canal of *Tricentrus albomaculatus*. The present study, therefore, deals with the digestive organs of a common membracid, *i.e.*, *Oxyrhachis taradus* Fabr.

II. MATERIAL AND TECHNIQUE

The adult insects were collected from Kikar (*Prosopis juliflora*) plants commonly growing in the college campus. The insects were killed in a cyanide bottle and dissected in normal saline under Carl Zeiss binocular. The alimentary canal was fixed in Bouins fluid. Sections 6 to 8μ thick were cut and stained in Ehrlich's Haematoxyline and Eosin. For cutting sections of the entire insect, freshly hatched adults with soft chitin, were similarly fixed, sections cut and stained.

III. DIGESTIVE ORGANS

The digestive organs comprise of the following :—

A. Organs of ingestion including mouth parts, hypopharynx, sucking apparatus & food-chamber etc.

B. Alimentary canal.

C. Salivary glands.

Mouth parts : These consist of a labrum, labium, a pair of madibular and maxillary stylets.

Labrum (Fig. 10 lr) : It is a short tapering structure reaching a little beyond the middle of the second labial segments. It narrows proximally to meet the distal end of the enticlypeus. Its dorsal surface is rough and convex, the lateral sides bear chitinous protuberances and the ventral is grooved proximally to lodge the mandibular stylets.

Labium (Fig. 1 lb) : It is a three jointed dark brown structure. A loose flexible tough membrane (mb), all round at its base, binds its first segment to the head. The whole stucture, when at rest, is lodged in between the coxae. Its first segment (1st) is richly clothed with stumpy dark chitinised outgrowths. The second segment (2nd) is the largest and is provided with fine bristles all around. The margins of the dorsal groove have two sets of progressively very long stout bristles, one of which, originating from the outer side, projects upwards and forwards while the other set projects horizontally forward intercrossing the bristles of the opposite margin. The distal end of this segment is knob-like (Fig. 2kb) and projects out in the segment with which it is movably articulated by means of a number of muscles. The third segment (3rd), smallest of all, tapers distally and resembles the preceding segment in colour. It is composed of two identical lateral components joined together ventrally by means of a membrane and dorsally by the labial plate. A whirl of stout bristles is prominently held out near the distal end. The labium is furrowed throughout its length by a dorsal groove (dg). It is wide proximally to accommodate the hypopharynx and narrows as it advances. It carries at its base a highly chitinised labial plate (lp), which runs all along its length to form the hard ground for the piercing apparatus. It extends into the head and ends in a knob (kn). The latter provides a place for the insertion of the protractor muscles of the labium. It slightly bends ventrawards in the first segment and widens leavinvg a gap in the middle (Fig. 10).

Mandibular stylet (Fig. 3 md) : Each mandibular stylet originates from the head region and lies in the bristle pouch (Fig. 8 bp). They are thick at the base and gradually taper distally. The tip of each is outwardly serrated with a

number of recurved teeth. The inner margin of each stylet is hollow (Fig. 5 md) to accommodate a maxillary stylet (mx). At the base there is a protractor arm, the lever (lr), articulating with the mandibular plate on the dorsal side.

Maxillary stylet (Fig. 4 mx) : They are thinner than the mandibular stylets. Each stylet on its inner margin carries two grooves (Fig. 5). When the two stylets lie opposed to each other, these grooves form two channels, viz., foodcanal (fc) and salivary canal (sc). A curved maxillary lever (lr) is attached at the base of each stylet. The other end of this lever is connected with the lateral plate of the hypopharynx.

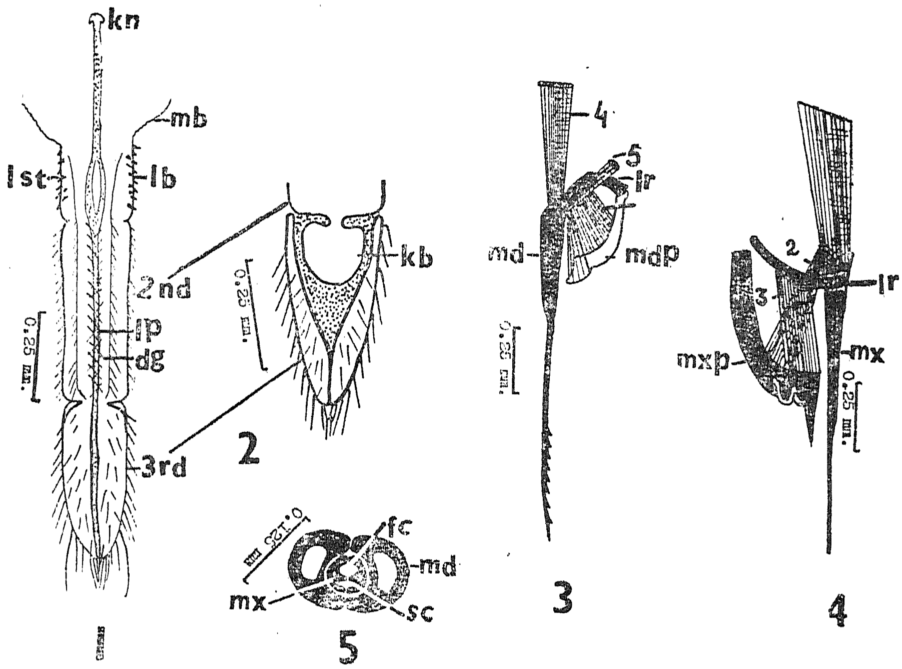

Fig. 1. Labium of *Oxyrhachis tarandus* Fabr. ; Fig. 2. Ventral view of the tip of the labium ; Fig. 3. Mandibular stylet ; Fig. 4. Maxillary stylet ; Fig. 5. T. S. of madibular and maxillary stylets showing food canal and salivary canal.

1st, First segment ; 2nd, second segments ; 3rd, third segment ; dg, dorsal groove ; kb, knob like distal end of the second segment ; fc, foodcanal ; kn, knob of the labial plate ; lb, labium ; lp, labial plate ; lr, lever ; mb, membrane ; md, mandibular stylet ; mdp, mandibular plate ; mxp, maxillary plate ; sc, salivary canal.

Hypopharynx (Figs. 6, 7, 8, 9 & 10 hp). : It resembles with that of other Homoptera in its general plan. It is a lobe protruding from the middle and lower surface of the head and forms the salivary pump (sp), the bases of the sucking apparatus (sa), and the food-meatus (fm). It is provided with the inner and outer broad lateral wings (lw), which extend into the cranial region and meet the tentorial arms (ta). Form the under side of these lateral wings arise fan-shaped muscles of the salivarypump.

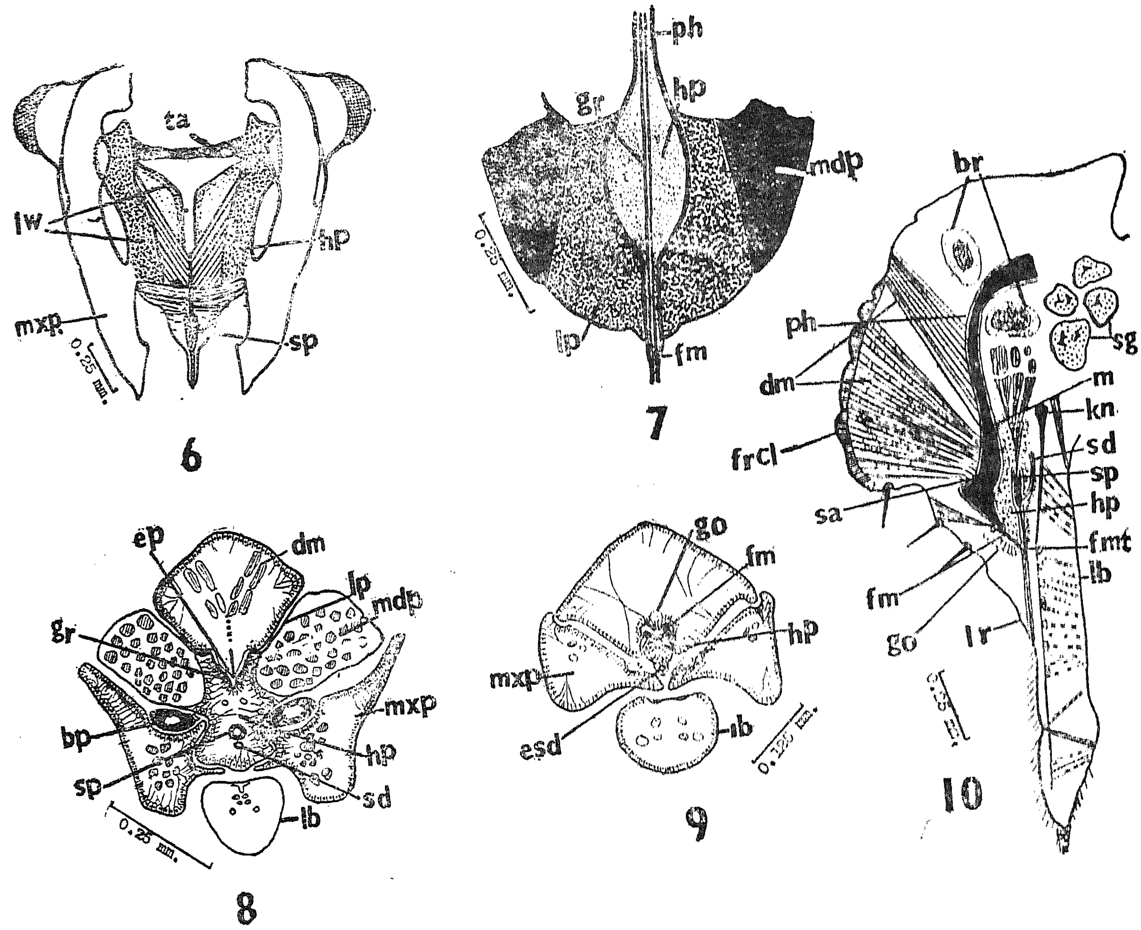

Fig. 6. Head dissected out to show the salivary pump, hypopharyngeal plate and tentorium , Fig. 7. Hypopharyngial part of the sucking chamber along with the lateral plates; Fig. 8. T. S. of the head passing through the sucking chamber or sucking apparatus ; Fig. 9. T. S. of the head passing throguh the food-meature ; Fig. 10. L. S. of the head.

bp, bristle pouch ; br, brain ; dm, dilator muscles ; ep, epipharynx ; esd, efferent salivary duct ; fm, food meatus ; fmt ; functional mouth ; frcl, frontoclypeus ; go, gustatory organs ; gr, groove ; hp, hvpopharynx ; kn, knob of the labial plate ; lb, labium ; lr, labrum ; lp, labial plate ; lw, lateral wings ; m, true mouth ; mdp, mandibular plate ; mxp, maxillary plate ; ph, pharynx ; sa, sucking apparatus or sucking chamber ; sp, sucking pump ; sg, s livary glands ; ta, tantorial arm.

Sucking apparatus (Figs. 7, 8 & 10 sa) : It consists of two boat shaped structures, viz., dorsal and ventral, one fitting into the other. The dorsal part, forming the anterior border, is made up of thin and flexible chitin called the epipharynx (ep), whose median edge, at the bottom, carries a ridge to fit into a groove (Figs, 7 & 8 gr) or the ventral or posterior part of the sucking apparatus. The ventral part of the sucking apparatus is formed by the hypopharynx. A number of dilator muscles (dm), arising from the lateral walls of the frontoclypeus (frcl) and arranged in v-shaped fashion, are inserted on the anterior or dorsal surface of the epipharynx. The lateral walls of hypopharyngial part of the sucking apparatus are strongly chitinised and continue sidewards to meet the lateral plates (Fig. 7 lp) which in turn are fused with the mandibular plates (Fig. 7 mdp). Anteriorly the chamber is connected with the food-meatus (fm) and posteriorly with the pharynx (ph). On the contraction of the dilator muscles, the epipharynx is raised upwards increasing the space in the sucking apparatus and creating partial vacuum. Consequently the liquid food from the food-meatus (fm) and food-canal (fc), rushes into the chamber to fill the vacuum. The junction of the food-meatus and sucking apparatus is not guarded by any valve. The various bundles of the dilator muscles do not relax simultaneously but the wave commences from the anterior side and travel posteriorly to the pharynx pushing the food with it.

Food meatus (Figs. 9 & 10 fm) : It represents the continued part of the sucking apparatus on the anterior side. The same components of the shucking apparatus, *i.e.*, epipharynx and hypopharynx, form this canal by the fusion of their lateral walls. This canal is prominently deflected posteriorly in its middle. Here a small powerful muscle, arising from the anticlyyeus, is inserted. The operation of this muscle controls the calibration of the food-meatus at this point to act as a valve for awarding sufficient opportunity to the gustatory organs (go) to exercise a satisfactory discrimination over the quality of food. This point further divides the food-meatus into a distal and proximal part. The distal part gradually narrows and ends into the functional mouth (fmt) into which opens the food-canal (fc). The wall of the epipharynx in this region is provided by a number of small pores arranged in a straight line and connecting the food-canal with the gustatory organs (Figs. 9 & 10).

Salivary pump (Figs. 6 & 8 sp) : It is a cylindrical stucture and receives anteroventrally a common salivary duct (sd). A thin a slightly chitinised diaphragm shuts the salivary pump at the back end. From the middle of this comes out a long solid chitinised rod over which a number of salivary muscles, arising from the hypopharyngeal plate, are inserted. The contraction of these muscles causes a vacuum in the salivary pump. This causes the saliva from the salivary duct to rush in.

Alimentary canal (Fig. 11) : It consists of three parts, *i. e.*, foregut, midgut, and hindgut. The foregut consists of pharynx (ph) and oesophagus (oe). The midgut or ventriculus is the largest part of the alimentary canal being about four times the length of the foregut. The hindgut consists of a narrow anterior long intestine (in) and a bulbous rectum (rm).

Foregut (Figs. 10 & 11) : It begins at the true mouth (m) which is situated at the posterior end of the sucking apparatus. The pharynx, first part of the foregut, commences at the base of this aperture as an elongated narrow chitinised tube. It is thin dorsally and thick ventrally. On its dorsal wall are inserted a number of dilator muscles (dm) arising from the head. It dilates posteriorly to form a small sac like structure resting upon the tentorial bar. Here it is surrounded

by numerous longitudinal muscles. The distinct epithelial lining is wanting and the cavity is internally lined by a smooth chitinous intima.

The pharynx continues posteriorly into a short greyish oesophagus (oe) which extends back upto the middle of the mesothorax. Posteriorly it swells up and into the first section of the ventriculus (Fig. 14 iven). The histological details of the oesophagus are similar to those of the pharynx except the epithelial lining, which is very well developed and consists of enlarged cells with one or two nuclei (Fig. 13). These cells are thrown into a number of ridges and furrows in the cardiac region. The junction of the fore and midgut is not guarded by a distinct valve.

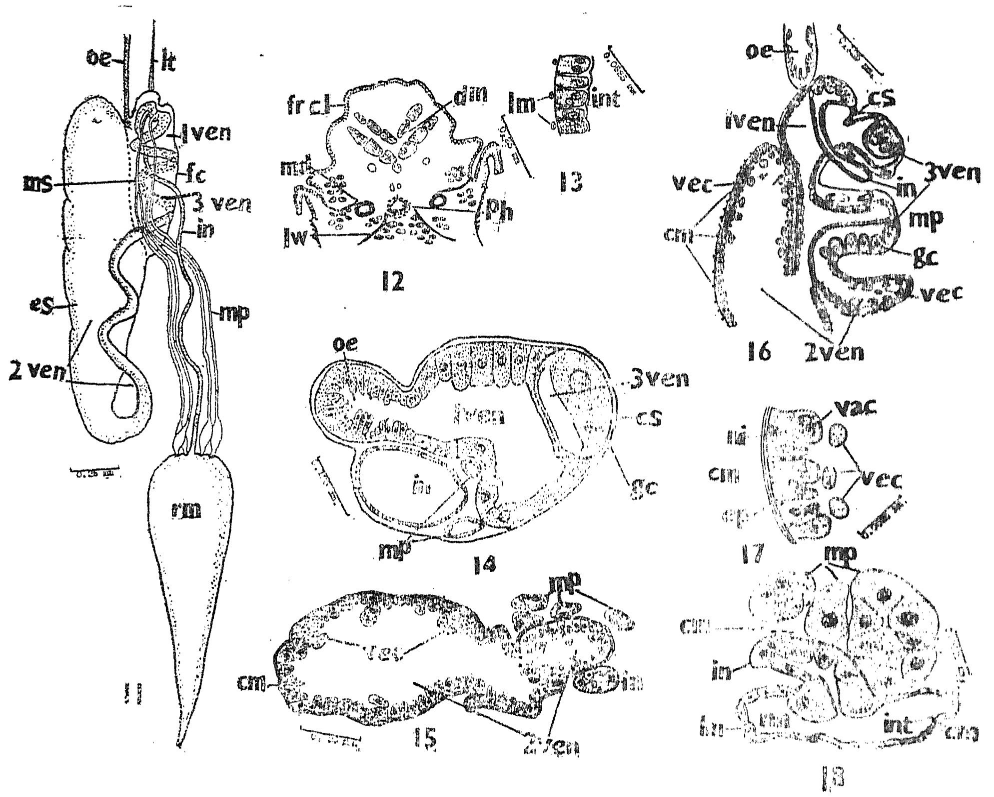

Fig. 11. Alimentary canal ; Fig. 12. T. S. passing through the posterior region of the head ; Fig. 13. T. S. of the wall of the oesophagus ; Fig. 14. T. S. of the filter-chamber at X.......X. in the figure 11 ; Fig. 15. T. S. of the mesenteron at Y....Y in the figure 11 : Fig. 16. L. S. of anterior region of the mesenteron ; Fig. 17. T. S. of the wall of the second section of the ventriculus ; Fig. 18 an oblique T. S. rectum showing the opening of the intestine in it.

cm, circular muscles ; cs, connective tissue sheath ; dm, dilator muscles ; ep, epithelium ; fc, filter-chamber ; frcl, frontoclypeus ; gc, giant cells ; int, intima ; in, intestine ; lw, lateral wings ; lt, ligament ; md, mandibular stylet ; mp, malpighian tubes ; ms, mesenteron ; ni, nidi ; oe, oesophagus ; rm, rectum ; vac, vacuoles ; vec, vescile ; lven, first section of the ventriculus ; 2ven, second section of the ventriculus ; 3ven, third section of the ventriculus.

The mesenteron or ventriculus (Fig. 11 mes) is the largest part of the alimentary canal and is confined to the metathoracic and abdominal regions. It is about four times length of the foregut. It is made up of two parts, *i.e.*, descending and ascending. The descending part is broad at the base but tapers as it runs forward. It constitues an anterior first section of the ventriculus (lven) and posterior second

section of the ventriculus (2ven). The former forms an important part of the filter-chamber and communicates with the second part of the ventriculus (Fig. 16 2 ven) by means of a narrow gap. The second part of the ventriculus is usually cream-colour. It is elongated sac like structure with irregular outlines. Posteriorly it gradully narrows, ascends up taking a turn to the left, describes a zigzag course over the descending part of the second section of the ventriculus and finally merges into the third section of the ventriculus inside the filter-chamber. The third section of the ventriculus (3even) lies enclosed within the filter-chamber. It runs up and down on the surface of the first section of the ventriculas and is inseparably attached with the latter. Anteriorly it forms two loops and then descends down to join the intestine (in).

The histological details of the ventriculus (Figs. 14, 15, 16 and 17) present a great diversity in different regions. The first section of the ventriculus (lven), together with the third, is enclosed within a thin connective tissue sheath (cs). The latter consists of a basal membrane of the epithelial cells and a thin membranous lining. The first section of the ventriculus (lven) forms a major part of the filter-chamber (fc). Its cavity is lined by broad columnar epithelial cells without any intervening space in between the cells. Each cells possesses a distinct cell-wall and is provided with round basal nucleus. This cellular nature is lost in the region which is in close contact with the third section of the ventriculus and is represented by a fine cytoplasmic strip (Fig. 14).

The epithelium of the ascending and descending parts of the midgut (except the part enclosed within the filter-chamber) is similar and yet it presents a great diversity in shape and size. At certain places the cells are considerably long while at others they are very short and flat. The transition from tall to short is gradual at some places and abrupt at others, The distal margin of these cells are free from one another and project into the lumen (Fig. 17). The cell-walls are distinct often touching each other in the basal region and at times distinct intervening space exists between the adjacent cells. The inner border of each cell contains radial striations. Each cell possesses one or two nuclei which may be round or oval. The cytoplasm is vacuolated (vac). The number and size of these vacuoles differ in different cells according to their physiological state. These vacuoles are liberated by the rupture of the cell-wall in the lumen. The inner border of these epithelial cells bud off cytoplasmic vesicles (vec) which may be with or without nuclei. At times, the budding is so profuse that most of the space of the lumen, especially that of the ascending part, is filled up with them. Similar type of vacuoles without nuclei have been reported from the midgut of *Typhlocyba ulmi* by Willis (1949). Their orgin has been traced by Saxena (1955) in cetain leaf-hoppers. He has noticed numerous vesicles flowing out from the midgut of freshly dissected leaf-hoppers. He believes that these vesicles are formed as a result of physiological activity of the epithelium. At the base of these epithelial cells there are cetain small cells called nidi (ni). The epithelium is surrounded by relatively less strongly developed circular muscles (cm) on the outer side.

The nature of these cells abruptly changes the moment the ascending part of the midgut enters the filter-chamber (Fig. 13 & 16). The wall of this part of midgut, *i.e.*, third section of the ventriculus (3ven), is lined with a few large or giant cells (gc), which although present on side, virtually occupy the entire space of the third section of the ventriculus. Each cell carries a large oval or elongated nucleus. The cytoplasm is non vacuolated. The histological details, on either side of the line of contact of this part of the midgut and first section of the ventriculus, are similar (Figs. 14 & 16). The two walls are inseparably united together and cellular nature is reduced to a mere thin cytoplasmic strips without distinct cell-wall.

The hindgut begins inside the filter-chamber. It consists of an anterior long intestine and a posterior short bulbous rectum, The former starts from the upper half of the filter-chamber just above the entrance of the oesophagus (oc) into the first section of the ventriculus, runs forward to the right, passes below the third section of the ventriculus and emerges out of the filter-chamber on forming a short of girdle round it. After leaving the filter-chamber it is accompanied by four malpighian tubes (mp) running in a convoluted manner to meet the inverted flask shaped rectum (rm). The anterior part of the intestine, present in side the fiater-chamber, differs considerably in histological details with the rest of the intestine. Its wall is composed of numerous small cells each of which contains a round basal nucleus. The posterior part of the intestine is composed of a few large cells without distinct cell boundary (Fig. 15). Outwardly the intestine is covered with a thin layer of circular muscles (Fig. 18cm). The lumen is lined with chitinous intima (int). The opening of the intestine into the reccum is guarded by a few bulged-out cells, which seem to exercise the function of a valve allowing the flow of liquid only in one direction. The cavity of the rectum is lined by flattened epithelial cells with a cuticular intima. Externally there are numerous circular and longitudinal muscles (Fig. 18,cm, lm).

Salivary glands (Fig. 19) : These glands consist of a pair of principal (psg) and a pair of accessory glands (asg). The former are situated in the anterior region of the prothorax and the latter project into the cephalic region on either side of the oesophagus. The principal gland is quadrilobed comprised of an anterior large lobe and the remaining three small lobes constitute the posterior part. A small stalk from each lobe joins together at a common point, the hilus (hl), which holds on the various lobes. The salivary duct, originating from the hilus, runs on either side of the nerve collar, ascends towards the hypopharynx and joins its fellow of the opposite side forming a common salivary duct (sd) which opens into the salivary pump (Fig. 10 sp). The accessory gland is vesicular in form. Its distal end continues proximally into a recurved grey terminal end which is connected with the hilus by short fine duct.

The anterior lobe of the principal gland consists of a number of cells which are broad at the base but narrow towards the centre where all of them open into a central canal (fig. 20 cn). Each cell shows two large nuclei which may be round or oval or irregular in outline. The cytoplasm is traversed by a large number of collecting vacuoles in different stages. Some of them are empty, where as others contain granules. Baptist (1941) believes that these vacuoles are no doubt developed as an adaptations to the exceptionally large size of the cell and also serve the purpose of storing up quite an appreciable quantity of secretion. The remaining posterior lobes are unicellular (Fig. 21). Each cell possesses two irregular nuclei with radiating processes extending into the cytoplasm. Vacuolisation in these cells is poor.

The accessary gland is made up of a single layer of glandular cells (Figs. 22 & 23). Its distal swollen part is made up of numerous enlarged conical cells (coc) which have a very narrow lumen within. Each cells possesses a distinct cell-wall and a basal nucleus. Minute vacuoles remify throughout the cytoplasm of each but the frequency of their occurrence is low as compared to the cells of the main gland. The presence of these vacuoles suggests that these glands also secret some substance. The distal swollen portion gradually merges with the narrow bent distal part of the gland. The lumen of this part of the accessary gland widens up because of the flattening of the cells (Fig. 23).

The salivary duct is formed by the fusion of two small ducts that arise at the hilus. The salivary duct is made up of a few cells without distinct cell-wall, but

possessing large round basal nuclei and vacuolated cytoplasm (Fig. 24). The canal (cn) is thickly chitinised in the middle. This structure is maintained for most of its length but its cellular nature is completely lost in the anterior region where a strong hollow chitinised rod opens at the bottom of the salivary syringe.

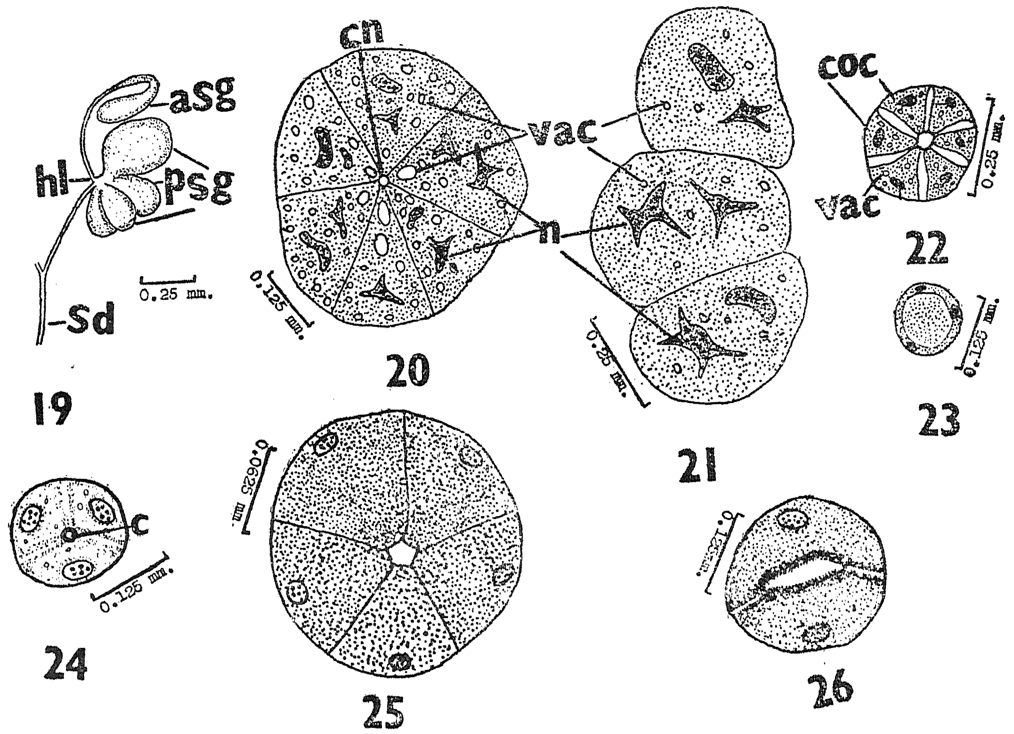

Fig. 19. Salivary glands; Fig. 20. T. S. of the anterior lobe of the main gland; Fig. 21. T. S. of the posterior lobes of the main gland; Fig. 22. T. S. passing through the posterior region of the accessory gland of the salivary gland; Fig. 23. T. S. passing through the anterior region of the accessory gland of the salivary gland; Fig. 24. T. S. of the salivary duct; Fig. 25. T. S. of the distal region of the malpighian tube; Fig. 26. T. S. of the proximal region of the malpighian tube.

asg, accessory salivary gland; c, central canal; cn, central canal; coc, conical cells; hl, hilus; n, nucleus; psg, principal salivary gland; sd, salivary duct; vac, vacuoles.

IV. MALPIGHIAN TUBES

There are four malpighian tubes in this insect. They arise at the junction of the third section of the ventricules and the intestine in the form of two thin stalks (ms), which, for some distance, run along the third section of the ventricules and leave the filter-chamber at the same place where the third section of the ventricules enters into it. But before their exit, each of them divides into two so that four malpighian tubes actually leave the filter-chamber (Fig. 11).

Each malpighian tube shows two distinct regions, i e., a proximal and a distal. The proximal two thirds of the tubule is semi-transparent duct with a wavy outline, nearly as thick as the intestine. Its wall is made up of two longitudinal rows of

uninucleate epithelial cells which are limited by a basement membrane and enclose a lumen in the centre (Fig. 26). The cytoplasm is finely granular and free margin of the cells show a radial striations towards the lumen. The distal one third part consists of a white spindle shaped structure and is followed by a short terminal part which rests in a small depression on the rectum. The wall of the spindle shaped region consists of a number of large cells which almost fill the lumen. Each cell is broad at the base and carries a peripheral nucleus longer than broad (Fig. 25).

V. DISCUSSION

Kershaw (1913), in *Tricentrus albomaculatus*, has shown that the major part of the alimentary canal is occupid by the foregut which consists of a short oesophagus and an elongated sac like crop. Its midgut or ventricules arises at the posterior end of the crop, ascends up following a zigzag course and then merges with the intestine inside the filter-chamber. The intestine leaves the filter-chamber in the form of along narrow tube and ends in a bulbous rectum. Although, this description was taken to be correct by Imms (1948), yet the fact was that most of the workers at that time had hardly understood the correct relation of the different parts of the Homopterous alimentary canal. Hickernell (1920) in Cicada and Cecil (1920) in Philaenus have shown thatt he midgut in Homopterous insect begins and ends inside the filter-chamber. In the light of the above observations, Snodgrass (1935) figured correctly the alimentary canal of *Tricentrus albomaculatus* and further divided the midgut or ventriculus into three parts, i.e., the first, second and third sections of the ventriculus. Thus the part, shown to be as crop by Kershaw (1913), is in fact made up of first and second sections of the ventricules and the midintesline as third section of the ventriculus. Snodgrass (1935) has further shown second section of the ventriculus as a sac like structure with a broad base anteriorly and gradually narrowing towards the posterior side. The third section starts at the posterior end of the second section of the ventriculus and ends inside the filter-chamber. Contrary to this, the histological details, i.e., (1) radical striations on the inner border, (2) the presence of the vacuoles in the cytoplasm and (3) budding off the cytoplasmic vesicles from the inner border of the epithelium and their subsequent presence in the cavities, of descending and ascending parts of the midgut (out side the filter-chamber) of *Oxyrhachis tarandus* Fabr., lead the author to believe that ascending part in this insect does not represent a new part but the continuation of the second part of the ventriculus. The third section of the ventriculus, lies enclosed within the filter-chamber. This section can easily be distinguished due to the presence of a few giant or enlarged cells on one side and the other side being reduced to a thin cytoplasmic strip, which, as already shown by Chandel (1958), after fusion with a similar strip of the first section of the ventriculus, forms a semipermeable membrane and allows extra quantity of water from the liquid food to pass from the first section of the ventriculus to the third and thence to the intestine.

V. SUMMARY

The organs of ingestion, anatomy and histology of the alimentary canal, salivary glands and malpighian tubes of *Oxyrhachis tarandus* Fabr., have been described in this paper.

The alimentary canal is usual but the midgut is comprised of three sections. The ascending part of the midgut, named by various authors as third section of the ventriculus, represents actually a continued part of the second section of the ventriculus and the third section in this insect is enclosed within the filter-chamber.

The Salivary glands are comprised of a pair of quadrilobed principal or main gland and a vesicular accessory gland. Their histology has been given in detail.

The malpighian tubes are four in number. Their distal end rest in rectal pockets.

VII. ACKNOWLEDGEMENTS

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VIII. REFERENCES

Baptist, B.A., 1941, The morphology and physiology of the salivary glands of Hemiptera, *Quart. Journ. Micr. Sci., London*, **83**, 91-139.

Cecil, R., 1930, The alimentary canal of *Philaenus leucopthalmus*, *Ohio. Jour. Sci.*, **30**, 120-128.

Chandel, B. S., 1958, Filter-chamber in *Oxyrhachis tarandus* Fabr., *Proc. Nat. Acad. Sci. Allahabad*, **28** (6), 424-426.

Hickernell, L. M., 1920, The digestive system of periodical cicada, *Tibicen septendecim*, *Ann. Ent. Soc. America*, **13**, 223-242.

Imms, A. D., 1948, Text Book of Entomology, London, 356-357.

Kershaw, J. G. C., 1913, Anatomical notes on a membracid, *Ann. Soc. Entom. Belgique*, **57**, 191-201.

Saxena, K. N., 1955, The anatomy and histology of the digestive organs and malpighian tubes of the Jassidae (Homoptera), *Journ. Zool. Soc. India*, **7** (1), 42-52.

Snodgrass, R. E., 1935, Principles of Insect morphology, New York & London, 386.

Willis, D. M., 1949, The anatomy and histology of the head, gut and associated structures of *Typhlocyba ulmi*, *Proc. Zool. Soc. London*, **118**, 984-1001.

SUSCEPTIBILITY OF ELEVEN VARIETIES OF TOMATO PLANTS TO SEPTORIA LEAF SPOT DISEASE

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INTRODUCTION

Leaf spot disease of tomato plants, caused by *Septoria lycopersici* Speg., was first reported in India from Coonoor (Ramakrishnan and Sundaram, 1954). Later the disease was found to be in a severe form in Kumaon region in Northern India (Gupta, 1958).

EXPERIMENTAL

Symptoms: The disease appears in the fields of Kumaon hills in the month of July when scattered, small, irregular and brownish spots appear near the margin of the distal leaflets of the older leaves (figs. 1 & 2). The infection then spreads to other leaflets, rachis, petiole and stem. Elongated spots are formed on the last three portions. The infeted leaves soon become chlorotic, then start drooping and ultimately fall down. Within a month the infected plants are left with 2-3 leaves at the top only (Fig. 3). Either the fruit formation is completely checked or if some fruits are formed they are small and shapeless.

Study of the fungus : Mycelium is septate and intercellular. Pycnidia develop in the centre of the spots and are hypophyllous, hemispherical and black in colour. Conidia are formed in large numbers and are long, slender, $45{\cdot}6\mu - 94\ \mu$ in length, $2{\cdot}5\mu - 3{\cdot}8\ \mu$ in breadth and 4-8 septate.

Susceptibility of different varieties of tomato plants : Fields of tomato plants in the vicinity of Naini Tal and Bhawali were regularly inspected during rainy season (July-September) in the years 1956 – 59. Septoria leaf spot disease of tomato plants was found to be in severe form in all the fields of this area. Complete loss of the crop was observed by the end of August in most of the fields.

To study resistance in different varieties of tomato plants, the seeds were sown in the month of June and a month later the seedlings were transplanted to the plots in which Septoria leaf spot disease was prevelent in the previous years.

The following eleven varieties of tomatoes were tested: Sioux, Golden Jubilee, Pusa Red Plum, Pusa Ruby, Sunny Best, Marglobe, Ox-heart, Ponderosa, Pritchard, Sun Ray and Naini Tal local. All the tested varieties started showing symptoms of the disease two weeks after their transplantation and by the end of August most of the leaves got infected and fell down. The symptoms were, however, comparatively less severe on the variety Pusa Red Plum.

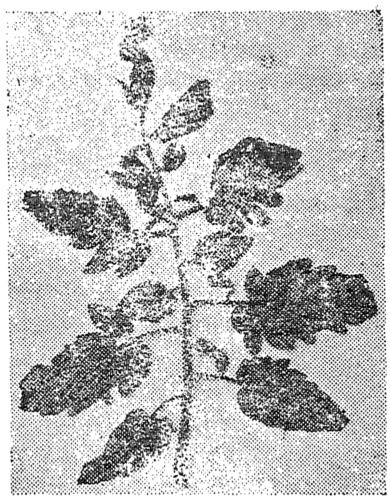

Fig. 1. An infected old leaf.

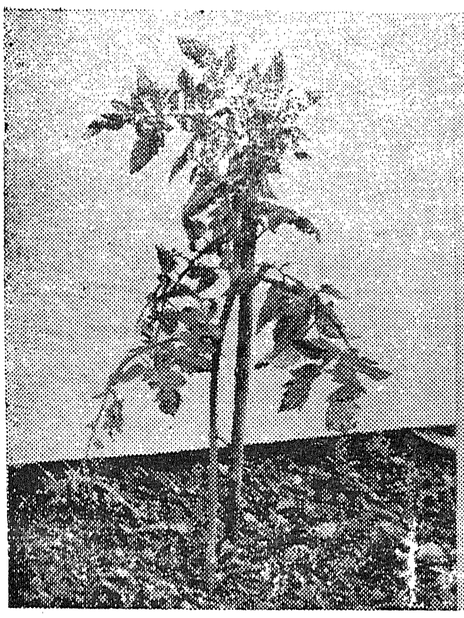

Fig. 2. An early infection. Older leaves show infection.

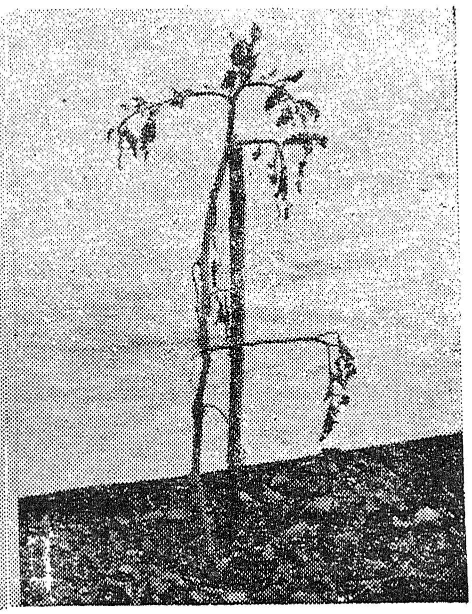

Fig. 3. Completely infected plant.

SUMMARY

Septoria leaf spot disease of tomato plants is prevelent in severe form in areas around Naini Tal. Eleven varieties of tomato plants were tested but none showed resistance to the disease.

REFERENCES

1. Gupta, S. C. 1958, *Septoria lycopersici* Speg. A serious leaf spot disease of tomato in Naini Tal area. *Proc.* 45th *Indian Sci. Cong., Part III*: 276.

2. Ramakrishnan, T. S. & Sundaram, N. V. 1954. Notes on some fungi from South India—IV. *Indian Phytopathology, VII*: 140-151.

CONTENTS

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